EXAMINING THE EFFECT OF DRUMS ALIVE® INTERVENTION ON VERBAL COMMUNICATION AND TASK ENGAGEMENT IN CHILDREN WITH AUTISM SPECTRUM DISORDER

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DEDICATION

This dissertation is dedicated to my father, Guangxing Yang (May 11, 1971 – June 17, 2017). You are my guide, mentor, and the wind beneath my wings. You taught me the value of hard work, perseverance, honesty, and respect for others. I wish you were here to see your handiwork and this manuscript. You are dearly missed.

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ABSTRACT

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EXAMINING THE EFFECT OF DRUMS ALIVE® INTERVENTION ON VERBAL COMMUNICATION AND TASK ENGAGEMENT IN CHILDREN WITH AUTISM SPECTRUM DISORDER

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Background: Children with autism spectrum disorder (ASD) may experience challenges with verbal communication (VC) and task engagement (TE) in daily and academic activities. Antecedent-based interventions (ABI) have been explored as evidence-based practices (EBP) to improve VC and TE for children with ASD. The purpose of this study was to examine the impact of Drums Alive® implemented as an ABI on VC and TE in children with ASD. **Methods:** Participants were five male children with ASD, aged 4–9 years, who completed an eight-week single-subject reversal design (A_1-B_1-A_2-B_2) study. In the A_1-B_1-A_2-B_2 research design, the baseline and intervention withdrawal phases (A_1 and A_2) consisted of six to eight 15 min observation sessions with the children with ASD engaged in structured activities (e.g., Legos, Jenga, hopscotch, beanbag tossing, etc.). The intervention phases (B_1 and B_2) consisted of six to eight 15 min Drums Alive® sessions followed by the same 15 min observation sessions. A 10 s partial interval recording method was used to collect data for the four phases, and all data were analyzed through visual inspection. **Results:** For all five participants, TE percentages were higher in the two intervention phases than in the baseline and intervention withdrawal phases, but no increases were observed for VC percentages in the two intervention phases. **Conclusion:** While limited, there appears to be support for Drums Alive® as an ABI to improve TE for children with ASD. However, further research with more participants is needed to confirm the impact of the Drums Alive® program.

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CHAPTER I

INTRODUCTION

Autism spectrum disorder (ASD) is currently one of the most prominent and widely discussed human conditions (Steinbrenner et al., 2020). In the fifth edition of the *Diagnostic Statistical Manual of Mental Disorder* (*DSM-5*), the American Psychiatric Association (APA, 2013) consolidated the diagnostic criteria for autism and three other types of disorders (i.e., Asperger syndrome, pervasive development disorder, and childhood disintegrative disorder) into a spectrum—ASD. ASD is defined as a neurological and developmental disorder that begins early in childhood and lasts throughout life (APA, 2013). In revising the diagnostic criteria, the *DSM-5* also included three severity classifications based on the degree of impairment in the domains of social communication and restricted and repetitive behaviors. These support levels are Level 1 ("Requiring support"), Level 2 ("Requiring substantial support), and Level 3 ("Requiring very significant support"). According to the diagnostic criteria in the *DSM-5*, a child around 3 years of age with persistent characteristic impairments in social interaction skills, social communication skills, and accompanied by repetitive and stereotyped behaviors would be diagnosed with ASD (APA, 2013). In addition to these core symptoms, some individuals with ASD also share genetic risks with intellectual disabilities (ID; Baio et al., 2018) and attention deficits/hyperactivity disorder (ADHD, Martin et al., 2014). Attention deficits include hyperactivity, inattention, and impulsiveness (APA, 2013). Concerning the comorbidity of intelligence deficits and attention deficits with ASD, Baio et al. (2018) reported that 33% of individuals with ASD have an ID, and Lai et al. (2017) wrote that roughly 28–44% of adults with ASD also have ADHD. Further, Reiersen and Todd (2008) purported that one of the most

significant impairments exhibited by individuals with ASD is a reduced ability to maintain an average attention span to a task.

Attending to tasks and engaging in required activities are documented challenges for children with ASD (Benson et al., 2020). When examining the cause of attention deficits, multiple researchers support that inattention and hyperactivity problems in ASD are caused by overlapping with ADHD (Antshel & Russo, 2019; Leitner, 2014; Mattard-Labrecque et al., 2013; Reiersen & Todd, 2008). Reiersen et al. (2007) proposed that ASD and ADHD originate from partially similar genetic factors, explaining why both disorders frequently occur within the same patient and family. In the current study, attention focuses on on-task behavior and task engagement (TE). Many children with ASD display disruptive or off-task behaviors associated with disruptions in the learning environment and decreased academic concentration (Sterling-Turner et al., 2001). Off-task behavior in children and youth represents a substantial societal and clinical concern (Finn et al., 2015). Low TE affects motor development, academic achievement at school, and daily adaptive life skills at home for children with ASD (Lei & Wang, 2018).

Communication impairment also significantly impacts motor development, academic achievement at school, and daily adaptive life skills at home for children with ASD (Hall & Segarra, 2007; Iverson, 2010). Brukner-Wertman et al. (2016) and Flax et al. (2019) claimed that social communication disorder is another name for the broad autism phenotype, which means there is genetic overlapping between ASD and social communication disorder. As indicated in the *DSM-5*, communication skill impairments in individuals with ASD include: (a) delayed in, or total lack of, the development of spoken language, (b) deficits in the ability to initiate or sustain a conversation with others, (c) stereotyped and repetitive use of language, and (d) lack of varied, spontaneous make-believe play or social-imitative play appropriate to the developmental level.

With attention and communication deficits, the impact of ASD can significantly limit an individual's capacity to participate in daily activities and engage in social activities. Further, ASD often negatively influences the educational and social attainments and employment opportunities for individuals (World Health Organization [WHO], 2021). Available scientific evidence suggests that there are probably many factors that make it more likely a child would have ASD, including environmental and genetic factors (WHO, 2021); however, the exact causes of ASD are unknown. The concern is given that the prevalence of ASD appears to be increasing globally, with 1% of the world's population diagnosed with ASD (Zablotsky et al., 2015) and 1.85% (1 in 54) of American children diagnosed with ASD (Baio et al., 2018). The increased prevalence of ASD has intensified the demand for effective treatments and educational interventions.

Treatments and Interventions for ASD

Pharmacological treatments (e.g., Amphetamine and Clonidine) are regularly used to treat individuals with ADHD (Davis & Kollins, 2012), and some parents choose to use these medications to treat attention problems for their child with ASD with ADHD comorbidity (Lamy & Erickson, 2018; Santosh et al., 2006). However, there are no pharmacological treatments for ASD symptoms, only for secondary health conditions, such as anxiety, depression, and pain (Hsia et al., 2014; Lamy & Erickson, 2018; Lamy et al., 2020; Murray et al., 2014). Instead, intensive behavior interventions applied in daily life and educational settings are the primary choices for improving outcomes for individuals with ASD, including communication skills and concentration (Palmen et al., 2012). Evidence-based psychosocial interventions, such as behavioral treatments, have documented effectiveness in reducing difficulties in communication

and social behavior; and positively impacting the well-being and quality of life of people with ASD and their caregivers (WHO, 2021).

The National Professional Development Center on ASD (NPDC, 2014) identified and reported on 28 evidenced-based practices (EBP) and interventions widely used in educational settings to improve outcomes for students with ASD, including communication skills and attending behaviors. According to NPDC, an intervention is considered to be an EBP if it is found to be effective in: (a) two high quality experimental or quasi-experimental group design studies conducted by at least two different researchers or research groups, or (b) five high-quality single-subject design studies conducted by three different investigators or research groups and having a total of at least 20 participants across studies, or (c) one high quality randomized or quasi-experimental group design study and at least three high-quality single-subject design studies conducted by at least three different investigators or research groups. Antecedent-based intervention and exercise were two of the evidence-based practices identified by the NPDC (Wong et al., 2015). Though not identified by NPDC, many researchers have provided empirical evidence to support music and rhythmic movement as an EBP for individuals with ASD (Kern et al., 2007; Oriel et al., 2011).

Antecedent-Based Intervention

Antecedent-based intervention is an EBP used to address interfering behaviors (e.g., repetitive or disruptive) and on-task behaviors (e.g., engaged or working on a specific task; Neitzel, 2010; Wong et al., 2015). An antecedent-based intervention aims to identify the factors that reinforce the identified interfering behaviors and then modify the environment to reduce the interfering behaviors (Texas Autism Resource Guide for Effective Teaching, n.d.). Educators can use an antecedent-based intervention to decrease identified interfering behaviors and increase

engagement by modifying the environment to change the setting's conditions, prompting the learner to engage in the interfering behavior (Autism Focused Intervention Resources and Modules [AFIRM], 2016). Specific to children aged 6–14 years, antecedent-based intervention can improve social skills, communication, on-task behavior, academic achievement, motor skills, and adaptive skills (AFIRM, 2016).

Exercise

According to Griffin (2015), exercise is commonly used as an antecedent-based intervention for individuals with ASD. Exercise refers to physical activity (PA) consisting of planned, structured, and repetitive bodily movements to improve and maintain one or more physical fitness components (Caspersen et al., 1985). The commonly used exercise types included in interventions for individuals with ASD include running, jumping, jogging, dancing, bouncing, and rolling (Neely, 2015; Oriel et al., 2011; Tse, 2020). Many practitioners use exercise as an effective intervention for learners with ASD to increase desired behaviors, such as academic engagement, time on task, correct responding, and task completion (Canella-Malone et al., 2011; Celiberti et al., 1997; Howie et al., 2012; Miramontes & Schwartz, 2016; Nicholson et al., 2010; Oriel et al., 2011; Sowa & Meulenbroek, 2012). Besides this, Menear and Neumeier (2015), through their research on the barriers, benefits, and strategies in promoting exercise for students with ASD, indicated that exercise could increase activity in areas of the brain associated with attention, focus, and motor coordination. Furthermore, exercise also improves overall physical health and fitness (Tomporowski & Pesce, 2019), decreases stereotyped and repetitive behavior (Bahrami et al., 2012), and increases communication skills (Bahrami et al., 2016) and emotional functioning (Pan & Frey, 2006) for individuals with ASD. Exercise also results in the release of endorphin hormones (Boecker et al., 2008) and dopamine (Foley & Fleshner, 2008).

Furthermore, endorphin hormones can improve mood (Dubnov & Berry, 2013), and dopamine can improve executive memory and happiness (Heijnen et al., 2016).

Though exercise has all the above-mentioned benefits (e.g., improving physical fitness, increasing desired behavior, and improving communication skills), learners with ASD often encounter barriers in participating in the exercise. For example, various behavior difficulties could result in low exercise adherence (Hauck et al., 2016; Theofilou & Saborit, 2013). Therefore, it is essential to explore strategies to increase exercise adherence to maximize the benefit of exercise for learners with ASD. The design could be to change the forms of exercise or integrate rhythmic music into exercising. The use of music to improve exercise adherence has been investigated. For example, Titus and Porretta (2012) have indicated that preschoolers with ASD demonstrated increased on-task behavior when participating in a music-focused gross motor movement session.

Music

In addition to increasing exercise adherence, music can also influence other human behaviors by affecting the brain and other bodily structures in observable, identifiable, measurable, and predictable ways to achieve nonmusical goals, including social communication goals (Reschke-Hernández, 2011). Researchers have reported unique attractions to musical stimuli and enhanced music ability for individuals with ASD (Bonnel et al., 2010; Lai et al., 2012; Ouimet et al., 2012), and similar neurological reactions when listening to music when compared to their typically developing peers (Gebauer et al., 2014). While individuals with ASD have demonstrated impairments in some regions of the brain versus neurotypical individuals (Ecker et al., 2012), the frontal lobe brain area that receives musical impulses is intact in individuals with ASD (Caria et al., 2011; Gebauer et al., 2014). In a review of the music

literature, Molnar-Szakacs et al. (2009) provided evidence that individuals with ASD have average or superior abilities with specific music processing components, musical understanding, and appreciation, contributing to the efficacy of music-based therapies for individuals with ASD.

Music-based interventions, including music therapy, are effective in improving social interaction, verbal communication (VC), engagement behavior, socio-emotional reciprocity, on-task behavior, and attention span (Carnahan et al., 2009; Fees et al., 2014; Geretsegger et al., 2014; Gunsberg, 1988; Kim & Tomaino, 2008). Dieringer and Porretta (2013) investigated music's effect on decreasing off-task behavior in four children with ASD. Dieringer et al. (2017) also explored the impact of music on increasing on-task behavior in five children with ASD. Both studies demonstrated that music, especially with lyrics plus instruction, can significantly decrease off-task behavior and improve on-task behavior. When moving with rhythmical music stimuli, learners with ASD can better organize, predict, and respond to tasks (LaGasse, 2017). Although music has not been identified as EBP by the NPDC, many empirical studies provide evidence of music's effectiveness as an intervention, including interventions that combine music with rhythmic movement.

Rhythmic Movement

Rhythmic movements are physical movements repeated at regular intervals, which in turn form a typical pattern or beat (Collins English Dictionary, n.d.). Within interventions, rhythmic movements (e.g., drumming, bouncing, rolling, or moving to music) are designed to stimulate beat synchronization and integrate motor coordination skills to enhance young children's motor, auditory, and self-regulatory functioning (William, 2018). Specific rhythmic movement programs have even been developed as interventions for individuals with ASD and ADHD, such as Rhythmic Movement Training International (RMTi), which is a movement-based, reflex

integration program that uses developmental movements, gentle isometric pressure, and self-awareness to rebuild the foundations necessary to help overcome learning, sensory, emotional, and behavioral challenges of children and adults (RMTi, 2010). Researchers have also explored rhythmic movement in empirical studies with children with ASD. Srinivasan et al. (2015) conducted an experimental study comparing the effect of three different interventions (i.e., rhythm, robotic intervention, standard-care treatment) on imitation/praxis, interpersonal synchrony, and motor performance. The rhythm and robotic interventions significantly positively impacted imitation/praxis, interpersonal synchrony, and motor performance compared to the standard of care. Ho et al. (2011) used group drumming as a rhythmic movement intervention and examined its effects on low-income children's social-emotional behaviors. They showed group drumming to significantly improve multiple domains of social-emotional behavior, including attention, anxiety, and defiance. The psychosocial therapeutic benefits of drumming include enhancing communication (Maschi & Bradley, 2010; Maschi et al., 2013) and concentration (Chen et al., 2019). Similarly, Guzic et al. (2011) examined the percussion effect on attention to task in children with ASD and reported that all participants significantly improved attention to task. Researchers have also provided empirical support for percussion-based interventions for people diagnosed with a stroke, traumatic brain injury, mental illness, Alzheimer's disease, and other dementias (Currie, 2004; Sung et al., 2012).

Although the individual interventions listed above (i.e., exercise, music, and rhythmic movement) have demonstrated effectiveness in improving communication skills and TE in children with ASD, a more comprehensive intervention may be needed to efficiently enhance VC and TE (Warreyn & Roeyers, 2014). There is a paucity of research exploring the effect of evidence-based interventions (that combine exercise, music, and rhythmic movement) on

communication skills and TE for individuals with ASD. The Drums Alive® (DA) program is one such evidence-based intervention that incorporates exercise, music, and rhythmic movement and may effectively improve outcomes for individuals with ASD.

Drums Alive® Program

Introduced in the United States in 2004 by Carrie Ekins, DA is an evidence-based program that applies fitness, drumming, music, and educational concepts designed to improve children and pre-teens' physical, emotional, and social health (Drums Alive, n.d.). When participating in the DA program, individuals drum, bounce, or roll on a big rubber ball (i.e., a 55-cm yoga ball) and move to the music. Individuals can imitate the instructor's drumming pattern or create a pattern when participating in the DA activities. The DA program has been well received and implemented with various populations, including seniors with chronic diseases, children with ADHD and learning disabilities, and young adults with intellectual disabilities. The Dementia Society of America awarded DA the Neuron Brain Health Award 2020 – 2021. The DA program has also been used as an intervention in multiple empirical studies. For example, Willemin et al. (2018) conducted a quasi-experimental study to examine the DA program's effect (i.e., Drumtastic) on social-emotional functioning for 14 children with ASD. Although the social and personal skills did not improve due to the intervention, all participants reported considerably higher enjoyment and fun ratings post-intervention. Yang et al. (2021) also conducted a pilot study to examine the effect of DA intervention on motor skills, attention, and behavior for young adolescents with ID and ASD. It was found that participants' attention was improved after the 8-week DA intervention. The DA program was used as an antecedent-based intervention in the current study.

Problem and Purpose Statement

Though many individual interventions are shown to be effective, each intervention (e.g., exercise, music, and rhythmic movement) has limitations. To date, no researcher has investigated the combined effect of these interventions on VC skills (i.e., verbally asking for help, responding to teachers, and verbally initiating a conversation) and TE (i.e., stay on task, use task materials, work on a project) for children with ASD. The DA program combines the known interventions of exercise, music, and rhythmic movement uniquely, and it holds a potential impact of the overall health, wellbeing, and attention on participants. Still, there is a lack of research to explore the role of the DA program in improving VC and TE in children with ASD. Therefore, the purpose of this investigation is to examine the effect of the DA program, implemented as an antecedent-based intervention, on VC and TE in children with ASD.

Research Questions and Hypotheses

A single-subject research design was employed in this investigation. The research questions and hypotheses are stated below:

Q1. Implemented as an antecedent-based intervention, does Drums Alive® improve verbal communication for children with ASD?

H1. It is hypothesized that there will be an improvement in the participants' verbal communication as measured by direct observation in structured activities (e.g., Jenga, Lego, writing, target tossing, etc.) following the antecedent Drums Alive® intervention.

Q2. Implemented as an antecedent-based intervention, does Drums Alive® improve task engagement for children with ASD?

H2: It is hypothesized that there will be an improvement in the participants' task engagement as measured by direct observation in structured activities (e.g., Jenga, Lego, writing, target tossing, etc.) following the antecedent Drums Alive® intervention.

Delimitations

This study was subject to the following delimitations:

1. Participants were preschoolers in North Texas enrolled in programming at a therapy-based center.
2. A small sample size of participants was used ($N = 5$).
3. The age of participants was 4 to 9 years.
4. The participants were limited to those with ASD, identified as needing Level 1 or Level 2 support.
5. A four-phase single-subject withdrawal treatment research design was used.
6. The principal investigator (PI) served as the DA intervention instructor.
7. The registered behavior technicians (RBTs) in the center provided support in all intervention and data collection settings.

Limitations

With a single-subject research design, this study has the following limitations:

1. Limitation of generalizing results. It is difficult to generalize the results to other populations with few participants.
2. Limitations of participants' variability. The participants with ASD have significantly different characteristics from each other.

3. Limitation of hardly controlled extraneous factors. Many co-variables could affect an observed causal relationship, such as different measures, persons, settings, and times.
4. Limitations of data analysis. When using the visual inspection data analysis method, the baseline phase may include a wide range of scores. It is hard to determine if the intervention phase produces a difference. Besides, the nature of the graph may prevent small but meaningful changes from being visually evident.

Assumptions

With a single-subject research design, this study used the following assumptions:

1. It intensively focuses on the behavior of individual participants.
2. It discovers the casual relationships by manipulating an independent variable, carefully measuring a dependent variable, and controlling extraneous variables.
3. It studies the solid and consistent effects that have biological and social importance.

Definition of Terms

Within the context of this study, the terms were defined as following:

1. Autism spectrum disorder (ASD): ASD is a neurological developmental disorder characterized by deficits in social skills, communication, and repetitive or restricted interests that typically manifest before 36 months (APA, 2013).
2. ASD severity levels: the support level defines ASD's severity levels. Level 1 means that individuals with ASD require only mild support; Level 2 means that individuals with ASD require substantial support; Level 3 means that individuals with ASD need extreme support in daily life activities and academic activities. All five participants were under Level 1 or Level 2 support in the current study.

3. Antecedent-based intervention: antecedent-based intervention is a collection of practices in which environmental modifications are used to change the conditions in a setting that prompts a learner with ASD to reduce interfering behaviors and increase on-task behaviors (Sam, 2016). In the current study, the intervention was implemented as an antecedent-based intervention.
4. Drums Alive® (DA): the DA is a program that combines exercise, music, and rhythmic movement. Participants engage participate in the DA activities by drumming, bouncing, rolling on a big rubber ball, or moving around the ball with locomotor skills to the music (Drums Alive, n.d.).
5. Exercise: Exercise is a type of physical activity consisting of planned, structured, and repetitive bodily movements to improve and maintain one or more components of physical fitness (Caspersen et al., 1985). The exercise types in the current study include walking, jumping, jogging, bouncing, and rolling.
6. Evidence-based practice (EBP): EBPs are strategies proven to be effective for most students through experimental research studies or large-scale research field studies (Vanderbilt University, n.d.). In the current study, the EPB include in the antecedent-based exercise intervention.
7. Music: Music is vocal, instrumental, or mechanical sounds combined in such a way as to produce beauty of form, harmony, and expression of emotion (Merriam-Webster, n.d.). In the current study, the music includes age-appropriate songs with strong rhythmic beats.
8. Rhythmic movement: Rhythmic movements are physical movements repeated at regular intervals, which in turn form a typical pattern or beat (Collins English

Dictionary, n.d.). In the current study, rhythmic movement is included as a part of the antecedent-based DA intervention.

9. Task engagement (TE): Engagement in academic activities is defined as flow or involvement (Meltzer & Hamann, 2005). In the current study, TE was when the participant exhibited compliance to any assigned activities from the investigator or the RBT. Three operational definitions for TE were: (a) stay on an assigned activity, (b) work on an assigned activity, and (c) use assigned activity materials.
10. Verbal communication (VC): VC refers to spoken language production to send an intentional message to a listener (McDuffie, 2021). In the current study, three operational definitions for VC were employed: (a) verbally responding to the investigator or RBTs' questions, (b) verbally initiating a conversation, and (c) verbally requesting for help from their RBTs.

CHAPTER II

LITERATURE REVIEW

The purpose of this investigation was to determine: (a) the functional relation between the antecedent DA intervention and VC in children with ASD, (b) the functional relationship between the antecedent DA intervention and TE in children with ASD. The following sections support the use of DA, which uniquely combines exercise, music, and rhythmic movement, as an antecedent-based intervention to improve VC and TE for children with ASD. The following literature review presents quality research articles to provide an in-depth understanding of the topics related to this investigation and the methodological designs for the current study (i.e., single-subject research design). The topics related to this investigation are: (a) effect of exercise on VC and TE in school-age students with ASD, (b) effect of music on VC and TE in school-age students with ASD, and (c) effect of rhythmic movement on VC and TE in school-age students with ASD.

Effect of Exercise on Verbal Communication and Task Engagement

Literature Search and Review Procedure

The literature review specific to the effect of exercise on VC and TE was conducted systematically. Potentially relevant articles published in the past 20 years (i.e., 2000-2020) were initially located through online indexing system searches with assistance from a reference librarian. The librarian and PI used the keywords to conduct the initial literature search using the indexing systems of Academic Search Complete, Education Source, SPORTDiscus, and Google Scholar. Keywords used for the initial search include “exercise,” “physical activity,” “verbal communication,” “communication,” “time on task,” “on-task behavior,” “task engagement,”

"academic engagement," "children," "school-age students," "autism," "autism spectrum disorder or ASD," "pervasive non-developmental disorder," and "Asperger syndrome."

After receiving initial search records, the PI and another reviewer (i.e., another doctoral candidate in the major of Adapted Physical Activity) independently assessed all the titles and abstracts to determine whether the studies met the inclusion criteria using a dichotomous scale. In disagreement, articles were re-assessed until a 100% inter-rater agreement was obtained. The PI also conducted a manual search for additional literature based on the reference lists from located articles. After determining the target literature, the PI and the reviewer independently evaluated the quality of all selected papers for this topic. Complete agreement (i.e., 100%) between the PI and the reviewer was obtained for each article's full-text quality evaluation. The inclusion criteria for the exercise literature were: (a) exercise, physical activity, or antecedent exercise was used as an intervention; (b) participants were school-age students, aged 3–21, and diagnosed with ASD, autism, Asperger syndrome, or pervasive non-development disorder (PDD); (c) dependent variables investigated included verbal communication, social communication, task engagement, on-task behavior, time-on-task, or academic engagement; (d) research published in the past 20 years (2000–2020) in peer-reviewed English journals; and (e) an experimental/quasi-experimental or single-subject research design was used (literature reviews and meta-analyses excluded).

Literature Quality Evaluation Technique

The Adapted Physical Activity Taxonomy (APAT), developed by Carano et al. (2014), was used to evaluate the quality of empirical research studies within the field of adapted physical activity. The APAT comprises two parts: (a) a review for the quality of the study and (b) a review for the level of recommendation. The APAT has an evaluation rubric for each of the four

types of research designs: (a) experimental/quasi-experimental design, (b) single-subject research design, (c) correlational design, and (d) qualitative design. The appropriate rubric was used to evaluate each section of a research article (i.e., introduction, method, results, and discussion). After reviewing each section, the following rating levels were used to decide the article's overall quality.

A Level 1 ranking indicates that the article met all quality indicators for each section and domain and is indicative of robust research quality; a Level 2 ranking indicates the research article failed to meet at least one of the quality indicators in a section and is reflective of moderate research quality; a Level 3 ranking indicates the research article was unable to meet at least one of the quality indicators in each section and is reflective of weak research quality. In addition to the quality, three levels of recommendation are used to indicate the strength of a recommendation for applying the research findings in adapted physical activity. When one of the following criteria is met, the recommendation level of that research is Level A: (a) the results of the study hold significant value and can be applied to multiple settings related to the adapted physical activity field, (b) consistent findings using randomized trials or relating to a systematic review, (c) interventions were validated and relevant to populations including individuals with disabilities. Level B recommendations include limited or inconsistent evidence about the adapted physical activity field. Level C recommendations include studies with recommendations based on opinion, consensus, practice, or field-based experiences or studies that do not directly relate to benefiting individuals with disabilities through PA. However, no recommendation is needed if the study is not relevant to the adapted physical activity field. The investigator can systematically evaluate the literature using this two-part review process. This process was followed within the current study for literature specific to exercise on VC and TE.

Literature Search Results

The initial search resulted in 80 articles on the exercise effect topic. Strictly following the inclusion criteria, the PI and the reviewer agreed that 10 articles met the inclusion criteria and were eligible for a complete evaluation. A descriptive summary of the 10 articles is presented in Table 1 in alphabetical order. Of the 10 studies, seven articles used a single-subject design with 20 participants involved in all seven studies. Among all 10 studies, 60% used jogging as the intervention exercise, which is consistent with the findings of previous literature reviews (Lang et al., 2010). Other exercise types included mini-basketball, locomotor, object manipulation, yoga, and dance. The majority (70%) of these interventions were implemented before academic activities as antecedent exercise.

The dependent variables of communication, TE, executive function, and stereotypical behavior were investigated within the evaluated articles. Even though this systematic literature review summarizes the effect of exercise on VC and TE, none of the studies focused exclusively on these two variables; instead, most of the articles concentrate on TE and stereotypic behavior as dependent variables. Although VC and TE variables were examined with other variables, these studies still provide evidence to support the use of exercise to improve VC and TE for school-age students with ASD (see Tables 1 and 2).

Table 1

Descriptive Summary of Exercise Effect on VC and TE – Experimental and Quasi-Experimental Literature

Study	Study design	Participant information		Exercise types	Outcomes
		Sample size	Age range (years)		
Oriel et al. (2011)	QED	*N* = 24	CA = 3–6	15 min jogging/ running	There was a significant improvement in the treatment group's correct response compared to the control group, with no significant difference in on-task behavior and stereotypical behaviors in both groups.
Tse (2020)	ED	*N* = 37	CA = 8–12	30 min jogging	The 12-week jogging intervention effectively improved emotion regulation and reduced behavior problems, including attention problems.
Wang et al. (2020)	QED	*N* = 33	CA = 3–6	40 min mini basketball training	After the 12-week mini basketball training, the intervention group preschoolers with ASD improved social communication, repetitive behavior, and executive function.

Note. CA means chronological age. ED means experimental design. QED means quasi-experimental design.

Table 2

Descriptive Summary of Exercise Effect on VC and TE – Single-Subject Literature

Study	Study design	Participant information		Exercise types	Outcomes
		Sample size	Age range (years)		
Lee et al. (2018)	SSD	*N* = 3	CA = 3–6	15 min locomotor activity or objects manipulation activity	All participants engaged in fewer stereotype behaviors following locomotor activities (post-) than pre-PA sessions but have an inverse effect in the object manipulation activities.
Miramontez & Schwartz (2016)	SSD	*N* = 3	CA = 4–6	5 min book reading/5min yoga/5 min dance party in the circle time	On-task behavior during journal writing increased after participating in the yoga or dance party activity.
Morrison et al. (2011)	SSD	*N* = 4	CA = 10–21	Antecedent exercise includes a therapy ball, stationary bike, scooter board, and moon shoes	Antecedent exercise and access to leisure items reduced problem behavior for all four participants. Antecedent exercise resulted in a modest post-intervention decrease in problem behavior for three of the four participants.
Nakutin & Gutierrez (2019)	SSD	*N* = 3	CA = 6–7	12 min jogging followed by 5 min walking or stretching	All three participants' percentage of academic engagement and executive function were increased in the intervention phase. All participants' engaged time increased.
Neely et al. (2015)	SSD	*N* = 2	CA = 7–8	10 min jumping on an indoor trampoline	Both participants demonstrated higher levels of academic engagement and reduced levels of stereotypy after the antecedent physical exercise.
Nicholson et al. (2011)	SSD	*N* = 4	CA = 9	12 min jogging and 5min walking and stretching	All participants' academic engagement increased. Students were observed to be more active in the classroom after the PA intervention.
Pokorski et al. (2019)	SSD	*N* = 1	CA = 5	10-15 min gross motor activities, sensory behavior integration (SBI), and seated	Participant's engagement was higher in the gross motor activities sessions compared with SBI and seated work sessions.

Note. CA means chronological age. SSD means single-subject design.

Literature Summary

Studies conducted by Nakutin and Gutierrez (2019), Nicholson et al. (2011), Oriel et al. (2011), and Tse (2020) all applied jogging as the antecedent exercise intervention to improve behavior function, TE, and executive function in school-age students with ASD. Tse (2020) conducted a 12-week jogging intervention for 15 children with ASD to improve emotion regulation and functional behavior. When compared with the children in the control group, the emotion regulation (e.g., children's overall mood, emotional expression, and self-awareness) and the functional behavior (e.g., social problems and attention problems) were significantly improved in children in the jogging intervention group. The results supported the authors' hypothesis that exercise intervention effectively improves emotion regulation and reduces external, internal, and total behavior problems.

Nakutin and Gutierrez (2019) also implemented a jogging intervention for three children with ASD using multiple baselines across participants' research design to examine the effect of antecedent exercise on executive function and academic engagement. The researchers documented increased academic engagement but not executive function. Nicholson et al. (2011) examined the effect of antecedent exercise (i.e., 12 min jogging plus 5 min walking and stretching programs) to improve academic engagement for children with ASD. It was found that only 12 min of a jogging activity is sufficient to increase academic engagement for children with ASD. Similarly, Oriel et al. (2011) examined the effect of jogging and walking on the frequency of correct responses and on-task behavior. While the frequency of correct responses increased after intervention, there was no change in on-task behavior in children with ASD.

Pokorski et al. (2019) and Lee et al. (2018) examined the effect of a gross motor activities program on engagement and stereotypical behaviors. Pokorski et al. (2019) applied three

structural antecedent activities (i.e., gross motor activities, sensory-based interventions, and seated work) to increase engagement levels, reduce vocal stereotypy, and reduce motor stereotype in one child with ASD. The results indicated that the participant's engagement level was generally higher during the gross motor activities intervention than in the sensory-based or seated work interventions. However, more participants and research are needed to provide robust evidence for these conclusions. Similarly, Lee et al. (2018) examined the effect of a locomotor and objective manipulation physical activity program on stereotypical behavior and TE in three children with ASD. In the three-component test sequence (i.e., pre-physical activity, physical activity, and post-physical activity), all three participants demonstrated lower post-physical activity stereotypic behavior after the intervention, but only one participant demonstrated increased TE during the intervention. The researchers suggested that TE has an inverse relationship with stereotypical behavior and that motivation is a significant factor affecting engagement in physical activities. Lee et al. (2018) recommended that future research also focus on motivation for children with ASD while using exercise as an intervention. Cumulatively, the research presented here provides evidence that TE and stereotypical behavior are improved in children with ASD through antecedent exercise interventions (Miramontez & Schwaetz, 2016; Morrison et al., 2011; Neely et al., 2015).

Finally, Wang et al. (2020) implemented a 12-week mini-basketball training program for 18 preschoolers with ASD to improve working memory functioning and social communication impairment and reduce repetitive behavior. Compared with the control group, the intervention group exhibited significantly better working memory and social communication performance. In addition to the effectiveness of exercise for improving TE and reducing stereotypical behaviors,

this study adds to the empirical evidence that exercise can also enhance social communication for children with ASD.

Exercise Effect on VC and TE Literature Quality Evaluation

In addition to the descriptive summary provided in Tables 1 and 2, an overview of the literature's quality is presented in Table 3, including the APAT quality level ratings and the strength of recommendation for the 10 evaluated articles. The evaluation quality criterion of experimental/quasi-experimental research design and single-subject research and the recommendation level decision procedure are presented in Appendix A.

Table 3

Exercise Effect on VC and TE Literature Quality and Recommendation Level Evaluation

Study	Quality Strength Level	Recommendation Level
Lee et al. (2018)	Level 2	Level B
Miramontez & Schwartz (2016)	Level 3	Level A
Morrison et al. (2011)	Level 3	Level A
Nakutin & Gutierrez (2019)	Level 3	Level A
Neely et al. (2015)	Level 3	Level A
Nicholson et al. (2011)	Level 3	Level A
Oriel et al. (2011)	Level 3	Level A
Pokorski et al. (2019)	Level 3	Level A
Tse (2020)	Level 2	Level A
Wang et al. (2020)	Level 3	Level A

Note. Level 2 means moderate quality, and Level 3 means weak quality. Level A means a strong recommendation, and Level B means a moderate recommendation.

Experimental and Quasi-Experimental Research Design Literature Quality Evaluation

Only one experimental design article (i.e., Tse, 2020) met the indicators needed for a Level 2 rating (moderate research quality). Two experimental design articles (i.e., Oriel et al., 2011; Wang et al., 2020) were evaluated as Level 3 (weak research quality). The common issues that appeared in all three studies were: (a) a lack of detail regarding participants' confidentiality information, (b) failure to assess the intervention fidelity, and (c) failure to report power. Tse et al. (2020) met indicators for a Level 1 rating across all sections, but it did not report power that dropped the rating from Level 1 to Level 2 (see Table 3).

Single-Subject Research Design Literature Quality Evaluation

The APAT evaluation results in Table 3 show that six of the seven (85%) single-subject research design articles had methods sections evaluated as weak (i.e., Level 3 rating). Five of the seven articles (71%) had results sections assessed as weak, which dropped the articles to the overall quality of Level 3. This weak rating results from the authors failing to provide essential details for replication in the articles' method and the result sections. Additionally, almost none of the single-subject design articles addressed threats to internal validity. Inadequate descriptions of the participant-related information (e.g., sampling technique, participant inclusion, exclusion criteria, and participant confidentiality protection) also contributed to Level 3/weak ratings. Additionally, in the introduction section, about 50% of the studies did not clearly state the research purpose and hypothesis. Only the article from Lee et al. (2018) met the indicators needed for a Level 2 rating when evaluated on the APAT. This study had the issues mentioned above, including those related to sampling technique and participants' inclusion criteria. However, unlike the other articles, Lee et al. did provide the essential participant-related details in another section of the article.

Exercise Effect on VC and TE Literature Recommendation Level

Although none of the 10 studies were evaluated with a Level 1 quality rating, nine studies were evaluated with a strong recommendation level (i.e., Level A) as the overall outcome from each study resulted in "significant value that can be applied to educational, recreational and disability sport settings" (Carano et al., 2014, APAT Level of Recommendations). Different types of exercise were proven to effectively improve on-task behavior and academic engagement in school-age students with ASD. Like the conclusion drawn by Dillon et al. (2017), the quality analysis among those articles suggested that as researchers move forward with designing and conducting the research to establish the evidence base, they need to be mindful of the research-practice gap. Moreover, researchers must provide the critical information in their method section that is required for replication.

Effect of Music on Verbal Communication and Task Engagement

Literature Search and Review Procedure

The review of the literature specific to the effect of music on VC and TE was systematically conducted. Potentially relevant articles published in the past 20 years (i.e., 2000–2020) were initially located through online indexing system searches with assistance from a reference librarian. The librarian and PI used the keywords to conduct the initial literature search using the indexing systems of Academic Search Complete, Education Source, SPORTDiscus, and Google Scholar. Keywords used for the initial search include "music," "music therapy," "verbal communication," "communication," "time on task," "on-task behavior," "task engagement," "academic engagement," "children," "school-age students," "autism," "autism spectrum disorder or ASD," "pervasive non-developmental disorder," and "Asperger syndrome."

After receiving initial search records, the PI and another reviewer independently assessed all the titles and abstracts to determine whether the studies met the inclusion criteria using a dichotomous scale. In the instance of disagreement, articles were re-assessed until a 100% inter-rater agreement was obtained. The PI also conducted a manual search for additional literature based on the reference lists from located articles. After identifying the relevant literature, the quality of all the selected articles for this topic was independently evaluated by the PI and the reviewer using the Council for Exceptional Children (CEC) quality indicators (Gersten et al., 2005; Horner et al., 2005). Full agreement (i.e., 100%) between the PI and the reviewer was obtained for each article's full-text quality evaluation. The inclusion criteria for the literature specific to music were: (a) music or music therapy was used as an intervention, (b) participants were school-age students, aged 3–21, and diagnosed with ASD, autism, Asperger syndrome, or PDD, (c) dependent variables investigated included VC, social communication, task engagement, on-task behavior, time-on-task, or academic engagement, (d) research published in the past 20 years (2000–2020) in peer-reviewed English journals, and (e) an experimental/quasi-experimental or single-subject research design was used (literature reviews and meta-analyses excluded).

Literature Quality Evaluation Technique

Since the APAT was developed to evaluate the quality of empirical research studies specific to the adapted physical activity field, other quality indicators were used to evaluate the quality of the literature specific to music's effect on TE and communication. In 2005, the CEC developed a series of indicators to evaluate the quality of research articles and to identify EBP in special education. Specific to the current literature review, the experimental research and quasi-

experimental research quality indicators and the single-subject research quality indicators were used to evaluate the literature found through the search.

Experimental and Quasi-Experimental Literature Quality Evaluation

Gersten et al. (2005) explored and presented quality indicators for experimental and quasi-experimental research in the Special Education field. These indicators were intended to evaluate the merits of a completed research report, article, proposal, dissertation proposal, and grant application and serve as a checklist for researchers to use as they developed their research designs. The quality indicators are defined as essential indicators and desirable indicators. The essential quality indicators include: (a) describing participants, (b) implementation of the intervention and description of comparison conditions, (c) outcome measures, and (d) data analysis (see Appendix B). Researchers use these indicators to evaluate literature as “acceptable" and "high" quality research studies. According to Gersten et al. (2005), a study would need to meet all but one of the essential quality indicators and demonstrate one of the qualities listed in the desired quality to be considered an acceptable quality research study. To be considered a high-quality research study, a study would need to meet all but one of the essential quality indicators and demonstrate at least four desirable quality indicators.

Single-Subject Research Design Literature Quality Evaluation

Horner et al. (2005) explored and presented a series of quality indicators to (a) define features of single-subject research methodology, (b) clarify the single-subject research methods for special education, and (c) offer objective criteria for determining when single-subject research results are sufficient for documenting evidence-based practice. The quality indicators include: (a) description of participants and settings, (b) dependent variables, (c) independent variable, (d) baseline, (e) experimental control/internal validity, (f) external validity, and

(g) social validity (see Appendix C). According to Horner et al. (2005), a study would need to meet all but one of the quality indicators to be considered as having "the 'acceptable' methodological rigor needed to be a credible example of single-subject research" (p.173).

Literature Search Results

The initial search resulted in a total of 98 studies. Strictly following the inclusion criteria, the PI and the reviewer agreed that 14 articles met the inclusion criteria. A descriptive summary of the 14 articles is presented, by research design, in Tables 4 and 5. Of the 14 studies, eight used a single-subject design, with 27 participants involved in all seven studies. The types of music intervention varied from study to study but can be summarized into the following categories: (a) noncontingent music, (b) music with lyrics and music with lyrics plus instruction, and (c) listening programs (e.g., different music tracks, auditory prompting system, and individually composed songs). Within the evaluated articles, the dependent variables of vocal stereotypy, communication, on-task behavior, TE, challenging behavior, behavioral responses, off-task behavior, attention to task, person engagement, follow a routine, greeting behavior, and mood were examined.

Table 4

Descriptive Summary of Music Effect on VC TE – Experimental and Quasi-Experimental Literature

Study	Study design	Participant's information		Music Type	Outcomes
		Sample size	Age range (years)		
Kalas (2012)	ED	*N* = 30	CA = 4–6	Simple and complex music therapy	Adding musical elements can help to facilitate joint attention for children with ASD.
LaGasse (2014)	ED	*N* = 17	CA = 6–9	Music therapy group and non-music social group intervention	Music therapy group intervention significantly improves participants' social skills and develops their joint attention compared with the non-music group.
LaGasse et al. (2019)	QED	*N* = 7	CA = 5–12	Music therapy intervention	Initial outcome data for brain responses and behavior indicated positive trends for the impact of music therapy on selective attention skills.
Pasiali et al. (2014)	QED	*N* = 9	CA = 13–20	Music attention control training	The results demonstrated positive trends and improvements in attentional control and switching and selective attention.
Simpson et al. (2013)	ED	*N* = 22	CA = 3–9	Self-operated auditory prompting system (tape recordings of music interspersed with prompts)	Children with autism were more engaged in the sung condition than the spoken condition, although there was considerable variability in engagement levels between participants.
Stamou et al. (2019)	ED	*N* = 42	CA = 5–8	Novel music and dance program	Music is a strong motivational factor for autistic participants and promotes engagement on task.

Note. CA means chronological age. ED means experimental design. QED means quasi-experimental design.

Table 5

Descriptive Summary of Music Effect on VC and TE – Single-Subject Literature

Study	Study design	Participant information		Music Types	Outcomes
		Sample size	Age range (years)		
Dieringer & Porretta (2013)	SSD	*N* = 2	CA = 4	Music therapy (lyrical songs with instrumental accompaniment)	Both participants exhibited marked decreases in off-task behaviors during the intervention (music) compared to baseline (no music).
Dieringer et al. (2017)	SSD	*N* = 5	CA = 5–6	Music with lyrics versus music with lyrics plus instruction	Both interventions can improve on-task behavior. Moreover, the music with lyrics plus instruction increased on-task behaviors to a greater extent than music with lyrics.
Francis (2011)	SSD	*N* = 12	CA = 9–19	Listening Program-A music-based auditory stimulation technique	The results demonstrated a more significant indication of positive change in attention to task and person engagement after TLP than traditional music.
Gibbs et al. (2018)	SSD	*N* = 2	CA = 4–7	Noncontingent Music and Functional Communication Training (FCT).	Task engagement was higher in the FCT condition, and it increased his ability to engage in a task.
Kern et al. (2007)	SSD	*N* = 2	CA = 3–5	Children's teachers sing the songs during the greeting routine.	The songs helped the children enter the classroom, greet the teacher or peers, and engage in play.
Montgomery et al. (2011)	SSD	*N* = 2	CA = 17	Sung and spoken conditions embedded into a computer-based intervention	The results of the study indicated a potential positive relationship between the self-operated auditory prompting system and the on-task behavior of the participants
O'Connor & Dieringer (2014)	SSD	*N* = 1	CA = 11	Songs (tracks of humpback whale sounds, didgeridoo music, tuba and piano, Pink Floyd, and "Old Man River")	It is hard to conclude the music's reactions, but the participants interacted and engaged in positive physical behavior (e.g., swinging) during the sessions when playing the whale sounds song.
Scalzo et al. (2015)	SSD	*N* = 1	CA = 12	Noncontingent music	The results suggested that the combined intervention resulted in more significant suppression of vocal stereotypy and increased occurrences of on-task behavior in both participants.

Note. CA means chronological age. SSD means single-subject design.

Literature Summary

Music intervention feasibility and group music intervention's preliminary efficacy on attentional control were examined with individuals with ASD. LaGasse et al. (2019) and Pasiali et al. (2014) demonstrated that group music intervention is feasible and acceptable for participants with ASD. Pasiali et al. (2014) documented using a group music intervention to improve attentional focus as measured by direct observation. In addition to direct observation methodologies, LaGasse et al. (2019) used electroencephalography (EEG) to measure brain response and the *Test of Everyday Attention for Children* to measure attention outcomes for 14 children (seven with and seven without ASD) before and after 10 sessions of music intervention. Based on the brain response data, the authors purported that music positively impacts selective attention skills in both groups of children with and without ASD. Like the findings from the exercise literature, there are many different types of music activities that have been used in research.

The types of music interventions include listening to or creating music (Francis, 2011; Kern et al., 2007), low tone versus high tone music (O'Connor & Dieringer, 2014), simple versus complex rhythm music (Kalas, 2012), and music with lyrics versus without lyrics (Dieringer et al., 2017). In their study of the on-task behavior of children with ASD, Dieringer and Sainato (2017) compared the impact of music with lyrics alone and the impact of music with lyrics in addition to instruction. They reported that both interventions increased the on-task behavior for all four participants. However, the music with lyrics plus instruction intervention had a higher effect on increasing on-task behavior than music with lyrics alone. Similarly, O'Connor and Dieringer (2014) assessed an 11-year-old male's behavioral response with ASD when listening to different music pieces. The measures of the behavioral response included eye movement,

expressive behavior, and body movement. The authors suggested that the participant responded differently to different music tracks and the participant favored the whale sounds and the didgeridoo music over other tracks of music. For example, under the effect of the whale song, the participant had a lower demonstration of the "chewing or pulling on clothes" behavior and the "no noise" behavior than three of the four other music conditions.

Given that only one participant was involved in the aforementioned study, the authors were cautious in their conclusions but did recommend that educators be aware of the tone and emotional expression of the music when working with students with ASD. Kalas (2012) investigated simple music and complex music on joint attention in children with ASD. The joint attention was defined as the participants and the instructor sharing attention to an object on purpose. The author concluded that simple music with precise and predictable patterns effectively elicited joint attention for children more significantly impacted by ASD. Conversely, complex music with variable patterns may be more useful when working with children with mild to moderate impacts of ASD. This study provides a guide for educators and practitioners to use when choosing music as an intervention for individuals with ASD.

Noncontingent music has also been investigated as an intervention to improve TE and reduce vocal stereotypy for children with ASD (Gibbs et al., 2018; Scalzo et al., 2015). Gibbs et al. (2018) combined noncontingent music intervention with response interruption and redirection intervention (RIRD) to reduce vocal stereotypy behavior and increase on-task behavior in children with ASD. The researchers reported that the combined intervention resulted in more significant suppression of vocal stereotypy and increased occurrences of on-task behavior than the RIRD intervention alone. Similarly, Scalzo et al. (2015) compared the effect of four interventions (including functional communication training and non-contingent music) on

reducing vocal stereotypy and challenging behaviors and increasing TE for a 12-year-old male with ASD. Scalzo et al. reported that all evaluated behaviors were improved more in the functional communication training than in the other interventions, including music.

Music interventions, including listening programs, have also been employed in educational settings (Francis, 2011; Kern et al., 2007; O'Connor & Dieringer, 2014) and employment training settings (Montgomery et al., 2011). Francis (2011) compared a music-based auditory stimulation technique (i.e., the Listening Program) with a typical music intervention to examine the effect on attention to task, person engagement, and mood for individuals with special needs ($N = 12$), including those with ASD. The Listening Program was shown to have a significant effect on concentration on task and person engagement with interaction, while the impact on mood varied by the participant. One interesting finding from this study was that the participants with sensory processing difficulties demonstrated tremendous improvements in attention to task and person engagement. As a result, the Listening Program was recommended for educational and field settings that include individuals with sensory processing problems. Kern et al. (2007) evaluated the effect of composing songs on the morning greeting routine and morning cycle time for young children with ASD. The researchers suggested that when the songs were used, the two participants followed the routine better, greeted more peers, and engaged longer in the playtime. In a similar study, Montgomery et al. (2011) applied an auditory prompting system to increase participants' on-task behavior in job performance. The auditory prompting intervention consisted of music recordings interspersed with promotions of self-evaluation and encouragement related to job tasks in employment settings. A positive relationship was found between the self-operated auditory prompting system and the participants'

on-task behaviors. When using music as a prompt, the participants' independence and on-task behavior were promoted.

In addition to the positive effects of music on attention and TE, researchers also examined the impact of music on communication and language learning (Blythe LaGasse, 2014; Simpson et al., 2013) and inclusion promotion (Stamou et al., 2019). For example, Blythe LaGasse (2014) examined the effect of group music intervention on joint attention, eye gaze, and communication in children with ASD. Compared to the control group, joint attention and eye gaze improved significantly in the music intervention group, though no significant difference was observed in communication skills. The author suggested that the non-significance of communication skills changes may have been due to the considerable variability in the participant's communication skills. Similarly, Simpson et al. (2013) used music to promote engagement for children with ASD in a language learning task. The authors reported that the participants' engagement level was higher when children sang the word than speaking the word. The authors claimed that using musical elements during an intervention can promote language skills development and enhance children's engagement with ASD. Likewise, Stamou et al. (2019) found improved engagement when using music to prompt inclusion for children with ASD in mainstream classes, and they recommend that music is a decisive motivational factor for engagement in more tasks and group cooperation for students with ASD.

Music Effect on VC and TE Literature Quality Evaluation

In addition to the descriptive summary provided in Tables 4 and 5, an overview of the CEC quality evaluation of the 14 articles is presented in Table 6. A closer examination of the quality of all experimental and quasi-experimental research design articles and single-subject research design articles is shown in Appendices C and D.

Experimental and Quasi-Experimental Literature Quality Evaluation

Using the CEC quality indicators for group experimental and quasi-experimental research in special education (Gersten et al., 2005), none of the six articles presented in Table 4 were evaluated as high-quality, though two of the six articles were evaluated as acceptable (i.e., Simpson et al.'s 2013; Stamou et al., 2019). The remaining four articles were evaluated to be below acceptable quality. Further, all six experimental/quasi-experimental studies failed to provide information on (a) the participants across groups, (b) differential attrition, (c) intervention implementation fidelity, or (d) the power analysis conducted.

Using the CEC guidelines and the six studies presented in Table 6, music was determined not to be an EBP. For music to be identified as an EBP, evidence from four acceptable-quality studies or two high-quality studies in the current review is needed. In this current review of literature, only two acceptable-quality studies were identified and evaluated. From the analysis of the literature using the CEC indicators, it is suggested that authors pay particular attention to the reporting of (a) detailed participants' information, (b) fidelity in intervention implementation, and (c) the power analysis conducted. More high or acceptable quality studies, consistent with these recommendations, are needed to establish music as an EBP for individuals with ASD.

Single-Subject Literature Quality Evaluation

Similar to the experimental research literature, only a limited number of studies were evaluated as high or acceptable quality concerning methodological rigor. As presented in Table 6, two studies were evaluated as high quality (i.e., Gibbs et al., 2018; Kern et al., 2007). Two studies were evaluated as acceptable quality (i.e., Dieringer et al., 2017; Scalzo et al., 2015). When evaluated using the CEC indicators, it was found that most of the studies (63%) failed to describe the process for selecting participants with replicable precision. A contributing factor to

this is that most of the single-subject studies evaluated used a purposive sample method with limited details so that other researchers could select individuals with similar characteristics. Little descriptions of the independent variables and how dependent variables were also measured negatively impacted the evaluation of replicable precision.

In conclusion, it is worth mentioning that, even though all studies met the social validity quality indicators, none of the eight studies comprehensively described the social validity measurement. All the dependent variables measured in the evaluated studies are socially important, and the implementation of the independent variables in the studies was practical and cost-effective.

Regarding single-subject research evidence supporting the use of music as an EBP, the studies were evaluated using the five criteria established by Horner et al. (2005), which include: (a) the practice is operationally defined, (b) the context in which the practice is to be used is defined, (c) the practice is implemented with fidelity, (d) practices in single-subject research should be functionally related to change of dependent measures, and (e) the experimental are replicated across a sufficient number of studies, and participants. All eight studies presented in Table 4 meet these five evaluation criteria and provide evidence for the use of music as an EBP. More high-quality research using music as an intervention is needed to bolster support for music as an EBP for children with ASD to improve communication and TE.

Table 6

Music Effect on VC and TE Literature Quality Evaluation

Study	Quality Level (acceptable/high quality)
Dieringer & Porretta (2013)	Below acceptable quality
Dieringer et al. (2017)	Acceptable quality
Francis (2011)	Below acceptable quality
Gibbs et al. (2018)	High quality
Kalas (2012)	Below acceptable quality
Kern et al. (2007)	High quality
LaGasse (2014)	Below acceptable quality
LaGasse et al. (2019)	Below acceptable quality
Montgomery et al. (2011)	Below acceptable quality
O'Connor & Dieringer (2014)	Below acceptable quality
Pasiali et al. (2014)	Below acceptable quality
Scalzo et al. (2015)	Acceptable quality
Simpson et al. (2013)	Acceptable quality
Stamou et al. (2019)	Acceptable quality

Rhythmic Movement Effect on Verbal Communication and Task Engagement

Literature Search and Review Procedure

The review of the literature specific to the effect of rhythmic movement on VC and TE was conducted systematically. Potentially relevant articles published in the past 20 years

(i.e., 2000–2020) were initially located through online indexing system searches with assistance from a reference librarian. The librarian and PI used the keywords to conduct the initial literature search using the indexing systems of Academic Search Complete, Education Source, SPORTDiscus, and Google Scholar. Keywords used for the initial search included "drumming," "group drumming," "percussion," "rhythmic movement," "verbal communication," "communication," "time on task," "on-task behavior," "task engagement," "academic engagement," "children," and "school-age students."

The PI also conducted a manual search for additional literature based on the reference lists from located articles. The identified literature that met the inclusion criteria was then read by the PI and is summarized in the next chapter. The inclusion criteria for the literature specific to the rhythmic movement were: (a) drumming, percussion, or rhythmic movement was used as an intervention, (b) participants were school-aged children, (c) investigated dependent variables included communication skills, social communication, task engagement, on-task behavior, time-on-task, or academic engagement, and (d) research was published in the past 20 years (2000–2020) in peer-reviewed English journals. For this review purposes, meta-analyses and systematic reviews of the literature were included along with original research.

Literature Summary

The combined database and manual searches identified a total of seven studies. The seven studies applied drumming percussion, or rhythmic movement as an intervention to improve attention, social skills, executive function, motor skills, and/or decrease behavior problems (see Table 7).

Table 7

Descriptive Summary of Drumming/Percussion and Rhythmic Movement Effect on VC and TE

Study	Study design	Participant information		Intervention Types	Outcomes
		Sample size	Age range (years)		
Benson et al. (2020)	SSD	*N* = 3	CA = 4–5	Playing vibrating toys, stomping feet, standing/walking/march to act out the theme-related task.	Sensorimotor activities embedded into circle time were useful for some participants at certain times to improve attention.
Lowry et al. (2019)	QED	*N* = 18	CA = 7–8	5-week rock drumming lessons	Reduction in hyperactivity and peer problems was observed after a five-week drumming intervention. Drumming program is recommended to implement in a school environment
Martin & Wood (2017)	QED	*N* = 41	Youth	Therapeutic music and Holyoake's Drumbeat program	The Drumbeat program has potential benefits in reducing post-traumatic stress symptoms and antisocial behavior and increasing mental wellbeing for young adolescent boys.
Ragone et al. (2021)	QED	*N* = 11	CA = 5–11	Observation of Social Motor Synchrony with an Interactive System (OSMoSIS) Rhythmic movement	When the OSMoSIS switches on, it motivated children with autism to consciously generated sounds by movements. Children with autism engage in more activities and interact with facilitators more.
Su et al. (2020)	SSD	*N* = 1	CA = 11	12 taiko drumming lessons	The taiko group lessons demonstrated the potential benefits of improving attention and social interaction for students with learning disabilities.
Vazou et al. (2020)	ED	*N* = 39	CA = 6–11	Rhythmic program vs. physical education program	It recommended accepting, adapting, and implementing a rhythmic movement program to develop motor skills and executive function for young children.
Yoo & Kim (2018)	ED	*N* = 52	CA = 12–15	Study one: Dyadic drum playing Study two: Rhythm-mediated music therapy intervention	Participants with ASD social skills were improved after receiving the rhythm-mediated music therapy intervention.

Note. CA means chronological age. ED means experimental design. QED means quasi-experimental design. SSD means single-subject design

Lowry et al. (2019) compared the drumming ability, motor skills, and social behavior of children with and without ASD before and after a rock and roll drumming intervention. The researchers reported positive changes in social behavior problems, such as hyperactivity, in the ASD drumming group following the 5-week drumming program. Martin and Wood (2017) implemented a DRUMBEAT program to improve the mental well-being, psychological distress, and antisocial behaviors of low socio-economic status adolescents. The DRUMBEAT program involved three parts (i.e., drumming with djembes, therapeutic discussions, and final performance). The authors reported that the DRUMBEAT program was effective in reducing psychological distress and antisocial behavior and effective in increasing the mental well-being of the participants. In their two-part study, Yoo and Kim (2018) explored the relationship between dyadic-drum playing and social skills and developed a rhythm-mediated music intervention for improving social skills in children with ASD. The first part of the study examined rhythmic cueing and tempo adjustment as correlated with social skills. Information gleaned from this examination was used to develop the rhythmic intervention that was implemented with adolescents (aged 12–15 years) with ASD. The authors reported higher engagement in joint action with their partner as a result of the rhythmic movement intervention.

In their comparative quasi-experimental study, Tryfon et al. (2017) compared the performances of children with and without ASD on auditory-motor rhythm synchronization tasks. The researchers reported that performance on the auditory-motor rhythm synchronization tasks was similar for both groups and that older participants performed better than younger participants in both groups; thus, providing evidence that children with ASD perform identically to their neurotypically developing peers on non-verbal rhythm synchronization tasks throughout childhood development.

Vazou et al. (2020) compared the effects of a 7-week rhythmic program and a physical education program on motor and executive functioning. The rhythmic program emphasized moving to music beats and moving in various rhythmic patterns with whole-body movements, clapping, and drumsticks. In contrast, the physical education program focused on gross motor skills and team sports, without emphasis on rhythm. The results indicated that both programs improved participants' motor skills and executive functioning, but participants reported more joy and fun when participating in the rhythmic movement program.

Summary

The systematic literature reviews presented in this chapter were designed to provide the reader with an in-depth understanding of the: (a) effect of exercise on VC and TE in school-age students with ASD, (b) effect of music on VC and TE in school-age students with ASD, and (c) effect of rhythmic movement on VC and TE in school-age students with ASD; as well as to evaluate the quality of the research specific to exercise and music. By examining the literature specific to the effects of exercise, music, and rhythmic movement on VC and TE, the PI is more confident in the proposed intervention's potential impact (i.e., the DA intervention).

This literature review also aimed to present justification for the use of single-subject methodologies in the current study. Like many of the research articles presented in this chapter, the current study proposes using a single-subject research design to examine the effect of the DA program, implemented as an antecedent-based intervention on VC and TE in children with ASD.

While experimental research designs with randomized control groups are considered the gold standard for research methodology in education (Odom, 2005), they require a relatively large number of participants to ensure sufficient power, which may be very difficult or not feasible in the intended area of study. Instead, as demonstrated by the single-subject research

design studies presented in this chapter, the single-subject research designs effectively examine the functional relationship between an intervention and the selected dependent variables. A deeper understanding of designing a quality single-subject study and analyzing and reporting the corresponding findings in a high-quality manner has been achieved through this reviewer and evaluation process.

CHAPTER III

METHOD

Participants

Participants Recruiting

A convenience sampling method was used to recruit five participants from a behavioral treatment center for children with ASD in North Texas (hereafter referred to as the center). The inclusion criteria for participants were: (a) aged four to nine years, (b) diagnosed with ASD and requiring Level 1 or Level 2 support, (c) have no latex allergies, and (d) can withstand the percussion sound (drumming). The center's director provided a written letter of support and agreed to support participants' recruitment through the center and the implementation of all research activities at the center. In an effort to recruit participants, flyers were posted on the information board in the center, and additional flyers were distributed by the center directly to potential participants' parents/caregivers. The flyer presented the purpose of the research, the inclusion criteria for participants, the potential benefits of participation in this study, including improved VC and TE for participants, and the PI's contact information. Approval from the Institutional Review Board (IRB) was obtained from Texas Woman's University before any research activities, including recruitment (see Appendix D). All participants' parents/caregivers signed a consent form allowing their children to participate in the research (see Appendix E). Additionally, all participants were asked to provide verbal assent by asking if they are willing to participate in the intervention activities (i.e., the DA intervention).

Participants Demographic Information

The pseudonyms for the five participants are Oliver, Ethan, Dylan, Jesus, and Elijah. The demographic information for all five participants is presented in Table 8. Based on information

provided by the RBTs and informal observation prior baseline phase, the two younger participants are non-verbal communicators and require Level 2 support, and the other three older participants have some VC and only need Level 1 support. All of them can independently do the assigned activities but require consistent promptings and redirections.

Table 8

Demographic Information of All Participants

Participant's name	Age (years)	Gender	Support Level	Verbal Communication Ability
Oliver	4.5	Male	Level 2	Non-verbal
Ethan	4.5	Male	Level 2	Non-verbal
Dylan	6	Male	Level 1	Single words
Jesus	6	Male	Level 1	Verbal
Elijah	6	Male	Level 1	Verbal

Oliver

Oliver is a 4.5-year-old boy, and he is the only African American participant in this study. He is a non-verbal communicator, but he can understand instructions. He carried a communication device with him, but during the 2-month research period, the PI did not see him use it. Oliver commonly engages in screaming, aggression towards the environment, flopping to the ground, staring at the window, or running away from tasks. Matching cards, pulling letters out of a foam shape, and stacking Jenga blocks are his favorite activities, and he has very limited ability to complete other activities. During the DA intervention, rolling and bouncing on the ball were his favorite activities.

Ethan

Ethan is a 4.5-year-old boy. He is a non-verbal communicator, but he was able to ask "help" and say "go" starting from the DA intervention of the current study. He can understand and follow instructions to complete activities. He has very serious hand-tapping repetitive behaviors. He also likes to put his hands into his mouth. During the DA intervention, rolling and bouncing on the ball were his favorite activities.

Dylan

Dylan is a 6-year-old boy. He has very limited conversation skills but is able to answer questions using one or two words, such as answering the color of the material, the letters' names, and the numbers. Dylan can follow the RBT's instructions to complete all tasks, but the RBTs must consistently remind him what to do. His preferred activity is to put letters in alphabetical order. Dylan likes staring blankly a lot at the ceiling.

Jesus

Jesus is a 6-year-old boy. Jesus has a huge verbal repertoire but has limited conversation skills with peers. He can independently request preferred items and is able to answer questions in one or two words. He followed all instructions very well and did not demonstrate any aggressive behaviors during the intervention and academic activities time. However, sometimes he likes to do things in his own way. His preferred activities are throwing balls and beanbags into a bucket, hopscotch, and match cards.

Elijah

Elijah is a 6-year-old boy, and he is the highest functioning participant among all five participants. He uses VC though most of the time his words are slurred. He can independently

request preferred items. His preferred activities are dancing following the Go Noddle videos, stacking wood Jenga blocks, and throwing balls and beanbags into a bucket.

Research Design

The purpose of this study is to examine the functional relationship between the DA intervention and the VC skills and TE of children with ASD. A four-phase ABAB single-subject withdrawal research design was employed using a non-intervention baseline phase (A_1) and an intervention phase (B_1), with each phase being repeated (A_2 and B_2). Verification of VC and TE should occur in response to the phase change. Introducing the intervention twice to compare the target behaviors with the two baseline phases was done to strengthen or validate the functional relationship between the target behaviors and treatment (Richards, 2018).

Settings and Materials

All data collection activities and intervention activities were implemented in an indoor fitness room in the center. All activities were executed in a manner that complies with the Centers for Disease Control and Prevention (CDC) COVID-19 pandemic guidelines. The fitness room is disconnected from other therapy rooms, and it is used to do workshops or training for the center staff or parents. Inside the room, there are two benches and one play table. The PI moved the table and benches to a corner to make space for the data collection and DA activities.

During the data collection period, the participant was instructed to play one or two of the activities presented in Table 9 (i.e., Jenga, Legos, underhand tossing activities, hopscotch, and writing/drawing tasks) for 15 min. The Jenga, Lego, and writing/drawing tasks were set on a table, and the participant was asked to complete those activities around the table in a sitting or standing position. The underhand tossing and hopscotch activities were completed in an open

space adjacent to the table and in a standing position. During the intervention period, the participant was instructed to complete a 15 min session of DA activities (e.g., bouncing on a 55 cm yoga ball, drumming on a 55 cm ball, or moving around a 55 cm ball using locomotor skills).

Table 9

Examples of Data Collection Activities with Descriptions

Activity Name	Description
Card Matching	• Match two cards with the same image • Match one card image with a word card • Sort cards into different themes (e.g., fruit themes, vegetable themes, animal themes, etc.) • Name/identify the image on the cards • Match a certain number of cards in a particular time (e.g., 5 minutes for eight matches, or category one theme cards in 2 minutes, etc.)
Jenga	• Build the Jenga block structure • Ask the child a question every time he/she pulls out a block • Ask the child to name the images on the block they pull out • Ask the child the color of the block they pull out • Ask the child the color of the block they want to pull out • Ask the child to add/count the blocks they have removed
Hopscotch	• Ask the child to hop/jump/walk forward on the hopscotch board • Ask the child to move in a different direction • Ask the child to choose their favorite shape on the board and jump to it • Ask the child to take turns with the RBT moving through the hopscotch board
Underhand Target Toss	• Ask the child to toss balls/beanbags into a bucket (bucket can be a different size and put in the various distances) • Ask the child to toss balls/beanbags into a bucket • Ask the child what his/her favorite color ball or bean bags is • Ask the child to finish a toss into a particular bucket

The PI provided all data collection activities materials (e.g., Jenga blocks, Lego, and writing books) and the DA intervention materials. The equipment of the DA activities includes five 55 cm yoga balls, five plastic baskets, five pairs of drumsticks, instructional support cards, a music player, a cell phone, and an iPad. The instructional support cards include drumming patterns (e.g., drum on the top of the ball, drum on the ground), locomotor skills (e.g., jog and walk around the ball), and animal imitations (e.g., hold drumsticks beside the mouth to imitate an elephant with long ivories, hold drumstick beside two ears to imitate a rabbit with long ears). Before the participant arrived at the intervention setting, three yoga balls were placed on the plastic buckets. All activities followed the CDC guidelines of maintaining social distancing, wearing masks, and disinfecting equipment. All activities in the intervention setting and the data collection settings were recorded using a cellphone camera. Videos were transferred from the phone to a password-protected computer in a locked university office immediately following the conclusion of each day's data collection.

Drums Alive® Intervention

The DA program that combines exercise, music, rhythmic movement, and drumming is the current study's intervention. The DA intervention protocol was developed by the PI and Carrie Ekins, the DA founder. In the current study, the DA intervention included locomotor skills (i.e., walking, jumping, jogging, and running); age-appropriate, child-friendly music (e.g., "What a Wonderful World") or percussion sounds created by participants; and rhythmic movements of drumming, bouncing, or rolling on the 55 cm yoga ball.

The drumming movements were comprised of different patterns, such as clicking two drumsticks overhead; using the drumsticks to strike the ball (e.g., on top of the ball, on the side of the ball, on the bucket base, or the ground) with two hands simultaneously or with one hand in

an alternating pattern. Each intervention lesson included the routine of greeting participants, a brief warm-up, a drumming pattern without music and locomotor skills (pattern 1), a drumming pattern with locomotor skills (pattern 2), a drumming pattern with music and locomotor skills (pattern 3), a short group game, and a brief cool down (see Table 10). The participants participated in the intervention on an individual basis. During the intervention period, the PI followed the prewritten lesson plan. Slight adjustments were made, if needed, to keep the participant engaged in the lesson. For example, the PI may change a drumming pattern (i.e., from two hands drumming simultaneously to alternating one-handed drumming) or the music selection to maintain the participant's engagement in the DA activities.

Dependent Variables

The dependent variables for the current study are VC and TE behaviors. VC and TE each have three conditional definitions for data recording (see Table 11). During the 15 min data collection period, the PI purposely asked each participant a total of five questions related to the structured activities. Examples of the five questions are: a) how you are doing today, b) do you want to play another activity now, c) what the color of the Jenga block on your hand is, d) what the name of the animal on your hand is, e) how many beanbags you tossed into the hoop.

Table 10

An Intervention Lesson Plan Sample

Routine	Activities	Time
Greeting	● Welcome ● Safety Rules/Reminder of safety rules ● Help participant wear heart rate monitor in the forearm ● Lesson Preview	about 2 minutes
Warm-up	● Short children's dance (e.g., Bunny Hop Dance) ● Bounce on the ball ● Stretch	about 2 minutes
Drumming Pattern 1 without Music	● 8 counts overhead click ● 8 counts hit on the top of the ball ● 8 counts hit on the side of the ball ● 8 counts hit on the ground ● Repeat at least 3 times and more	about 2 minutes
Drumming Pattern 2 with Locomotor Skills	● 8 counts hit on the top of the ball ● 8 counts hit on the top of the ball & circle walk to the right ● 8 counts hit on the top of the ball & circle walk to the left ● 8 counts hit on the top of the ball again ● Repeat at least 3 times and more	about 2 minutes
Drumming Pattern 3 with Music	● Use music like "We Will Rock You" for different drumming patterns. o Pattern 1: 2 counts hit on the top of the ball, and 1 count click two drumsticks o Pattern 2: 1 count right hand hit on the top of the ball, one count left hand hit on the top of the ball, and 1 count click the two drumsticks.	about 2 minutes
Game Time	● RBTs and participants will create their own drumming pattern, and then they will take turns demonstrating the pattern to other participants and RBTs.	about 3 minutes
Cool Down	● Slow rhythm music will be played, such as "What a Wonderful World," the participants will stretch their hands and arms while walking around the space and following the PI's instructions.	about 2 minutes

Table 11

Operational Definitions for VC and TE

Dependent Variables	Operational definitions
Verbal Communication	● Respond to the PI's and RBTs' questions verbally ● Initiate a verbal conversation with the PI or the RBTs ● Verbally ask for help
Task Engagement	● Stay on assigned activities ● Work on assigned activities ● Use activities materials

Dependent Variables Measurement

VC and TE were measured and recorded using 10 s partial-interval direct observation from the recorded videos. Direct observation is the most used and the most appropriate analysis method in single-subject research design (Horner et al., 2005; Kennedy, 2005). An expert trained the PI in the single-subject research design to record the dependent variables and analyze them. The expert also assisted the PI in developing a data recording manual that includes all recording procedures and recording tables. The PI then trained a second data analyst, and they both used the data recording manual to view the videos and record all data points independently. Based on the dependent variables' operational definitions (see Table 11), a 10 s events-based partial interval recording method recorded VC and TE behaviors. The 15 min data collection period was divided into 90 separate 10 s intervals (see the Recording Manual and Recording Form in Appendix F). For example, when the data analyst records the VC behavior during the first 10 s interval, this interval was marked as "yes" as long as the participant had demonstrated one of the

identified VC behaviors (i.e., verbally responding to the PI's and the RBTs' questions, verbally asking for help, or verbally initiating a conversation). The same recording method was used to record the remaining 89 intervals. After recording all 90 intervals, the number of the intervals marked as yes was summed (e.g., 42 intervals out of 90 intervals were marked as "yes"). The percentage of time of the dependent variable was calculated using the following formula.

$$\frac{\text{Total of Intervals Marked as "Yes"}}{\text{Total Intervals}} \text{ X } 100\% = \text{Percentage of Total Time}$$

$$\frac{42 \text{ Intervals}}{90 \text{ Intervals}} \text{ X } 100\% = 47\%$$

The resulting data point for this participant's percentage of VC was 47%. The same recording method and calculating method were used across all data points in the four phases.

Data Collection Procedure

There was a total of four phases, including the baseline phase (A_1), the first intervention phase (B_1), the washout phase (A_2), and the intervention phase (B_2). Each phase lasted approximately 2–4 weeks, with three sessions being conducted weekly. In the baseline phases (A_1 and A_2), each session was 15 min in duration. In the intervention phases (B_1 and B_2), each session was 30 min in duration (i.e., 15 min intervention and 15 min data collection). Changes between phases (e.g., changing from baseline to intervention phase) depended on the data pattern. In the baseline phase, measurements were taken until a pattern emerged. According to Engel and Schutt (2016), the three common types of patterns are a stable line, a trend line, and a cycle. A stable line is a relatively flat line with little variability in the scores so that the scores fall in a narrow band. A trend line is an ascending or descending line, while a cycle is a pattern reflecting ups and downs depending on the time of measurement. As a rule, more data points lead to a more evident pattern. At least three consecutive measures are required to form a pattern.

The baseline phase typically continues, if practical, until there is a predictable pattern. While establishing a pattern requires at least three measurements, the current study collected at least five measurements before looking for a pattern to emerge (i.e., a stable line, a trend line, and a cycle line). Barlow and Hersen (1984) recommended that the treatment phase's length be the same as the baseline phase. This recommendation was followed in the current study.

The PI instructed the participant to start one of the structured activities presented in Table 8, then after a 5 min period, the PI asked participants if they would like to change to a different activity or stay on the same activity. The same procedure occurred after each 5 min period across the 15 min data collection period. During that same 15 min period, the PI purposely asked each participant five questions related to the structured activities. The PI recorded all the participant's performances and behaviors during the 15 min period using a cellphone camera. The same procedures for giving instructions, prompting an activity change, asking participants five questions, and recording participants' performance were used across all four phases.

Data Collection in Baseline and Washout Phases

In the baseline and washout phases (A_1 and A_2), participation involved only data collection activities. All participants were individually video recorded for a period of 15 min, while they were being asked to engage in the structured data collection activities. To begin the 15 min period, the PI instructed the participants to begin with one of the provided structured data collection activities. It followed the above-described data collection procedure. Each participant had three 15 min data collection periods recorded until stable data were obtained. The PI and another data analyst independently watched the videos to code the two target behaviors for each participant using the predefined criteria (see Table 11). After baseline (A_1) data indicated one of the above-mentioned patterns (i.e., a stable line, a trend line, or a circle), the first intervention

phase (B_1) began. This procedure was used for the second baseline. Both A_1 and A_2 phases followed the same data collection procedures as described above.

Data Collection in Intervention Phases

As described in this section, the intervention procedures and data collection procedures were implemented in both intervention phases. The intervention phase consisted of two parts: the DA intervention and structured data collection activities.

Each participant received a 15 min DA intervention on an individual basis. In each intervention session, the PI set equipment before the participants arrived in compliance with CDC guidelines. The intervention equipment consisted of three 55 cm rubber yoga balls, three bucket bases, three pairs of drumsticks, a music player, and instructional support cards. All equipment was disinfected before and after each participant's participation. When the participants arrived, the PI started the DA intervention using the routine presented in Table 10. The PI greeted the participant, explained the safety rules, and then proceeded with the prewritten lesson plan. The prewritten lesson plan began with a brief warm-up of bouncing and rolling on the ball 10 times, followed by jogging two laps around the ball. After the warm-up, the PI started the DA drumming patterns, and the participant followed/imitated the PI's movements. After completing three drumming patterns, the PI asked the participant to demonstrate a pattern he learned. The PI then followed the participant's lead and imitated his pattern. The PI concluded the DA session with a brief cool down by sitting on the ball relaxing and taking deep breaths in and out while practicing, stretching legs and arms, or walking around the ball with slow rhythm music. Both intervention phases followed these intervention procedures.

Field Notes

The PI took field notes during the act of conducting the study to accurately recall and document the behaviors, activities, events, and other features of observation during each study session. Field notes are intended to be read by the researcher as evidence to produce meaning and understand the culture, social situation, or phenomenon being studied. The notes included two types of information, which are descriptive information and reflective information. The descriptive information accurately documented factual data and the settings, actions, behaviors, conversations that the PI observed, and comments from the RBTs. The reflective information included documenting the PI's thoughts, ideas, questions, and concerns during the observation. The PI took both types of field notes during each session. The field notes data were used to assist the data analysis in the later process.

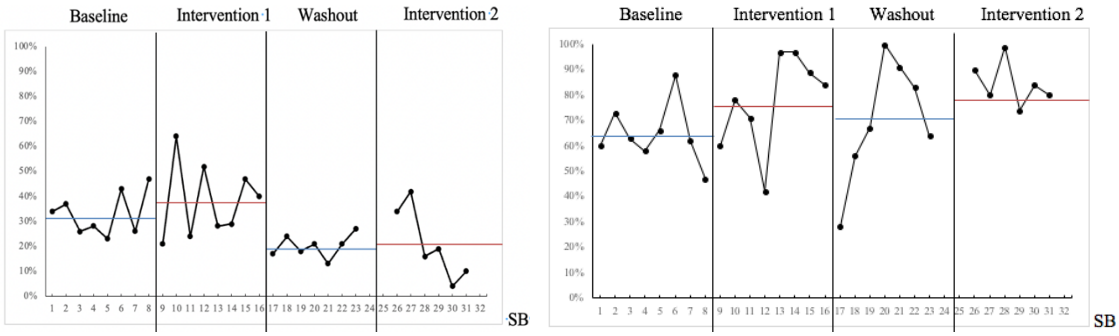
Obtaining the Data and Plotting the Results

After recording data for the two target behaviors, the results data were plotted on a line graph (see Figure 1) to display the functional relationship between the intervention (i.e., DA intervention) and the dependent variables (i.e., VC and TE). Each participant's target behavior is shown in a separate graph. The visual analysis was used to analyze the graphically depicted data. Visual analysis of data is used generally when continuous numerical data are gathered. When the researcher wishes to make formative as well as summative analyses of study outcomes, it is useful to graphically depict the data. There are two overall aspects of the data analyzed: level (i.e., performance on the dependent variables) and trend (i.e., changes or consistent patterns in the data path; Richards, 2018). More specifically, the researcher should examine the number of data points and the mean of their performance in each phase and across all phases, the variability of performance, the direction and degree of trends that occur, and the overlap of data across

study phases (Richards, 2018). The PI presented the results of each of these levels and trends-related examinations in Chapter 4.

Figure 1

VC and TE Intervals Percentages Graph Sample



(a) Verbal Communication Interval Percentage (b) Task Engagement Interval Percentage

Inter-Observer Reliability

Inter-observer reliability in the partial interval recording was based on an interval-by-interval appraisal of agreement. That is, each observer's recording of occurrence or nonoccurrence was compared for each interval. Comparing the two observers' recording results verified inter-observer agreement if the agreement was above 80%. For each data point, 80% of the inter-observer agreement between the PI and the second analyst needed to be obtained. If the inter-observer agreement fell below 80% for any data points, the PI and second data analyst re-recorded that data point until an 80% agreement rate is achieved. The inter-observer agreement rate was calculated using the following formula:

$$\frac{\text{Number of Agreement Intervals}}{\text{Total Intervals}} \text{X } 100\% = \text{Inter-observer Agreement Rate}$$

Internal Validity

Findings of causality depend on the internal validity of the research design. When repeated measurements are taken during the baseline phase, several threats to internal validity are

controlled. Specifically, problems of maturation, instrumentation, statistical regression, and testing may be controlled by the repeated measurement because patterns illustrative of these threats to internal validity should appear in the baseline. When baseline measures are stable lines, these threats may be ruled out. The most significant threat to internal validity is history. Repeated measurement in a baseline controlled for an extraneous event (history) that occurs between the last baseline measurement and the first intervention measurement. Therefore, after the baseline data is collected, the PI debriefed subjects to determine whether some other event may have influenced the results.

In a control group design, random assignment controls for threats to internal validity. In a single-subject design, the repeated baseline measurements allow the researcher to discount most threats to the internal validity of the design (Engel & Schutt, 2016). In addition, the participation schedules of each participant were decided by the center director, not by the PI, which would increase the randomization in the current study.

Fidelity

Intervention fidelity is the degree to which the researcher, through systematic observations by two or more raters, can verify that the intervention was consistently carried out according to the prescribed procedure (Richards, 2018). Intervention fidelity should include assessing the implementation of the intervention (e.g., by day or week) and coverage of a specified amount of material, curriculum, or similar guide when appropriate (e.g., a minimum of 3 min warm-up; Gersten et al., 2005). In the current study, the intervention fidelity was evaluated similarly to the inter-observer agreement. All sessions of intervention were videotaped, then the two observers, who recorded target behaviors, used the videotape to rate the intervention fidelity with a predesigned intervention protocol. The protocol included the schedules of interventions

and the contents of each intervention. If the agreement rate for the two observers was above 80%, it would verify the intervention fidelity.

Pilot Study

Pilot Study Objectives

According to Thabane et al. (2010), a pilot study is the first step in developing the research protocol and is often a smaller-sized study conducted to assist in planning and modifying the main study. By conducting a pilot study, multiple objectives are met including: (a) improving the quality and efficiency of the main study, (b) assessing the safety of treatment or interventions and recruitment potentials, (c) examining the randomization and blinding process, (d) increasing the researchers' experience with the study methods or medicine and interventions, and (e) providing estimates for sample size calculation (In, 2017). The pilot study is also a check for the reliability and validity of the research method.

Specific to the current study, a pilot study was conducted with three participants with ASD in order to: (a) assess the safety of the DA intervention in children with ASD, (b) examine the feasibility of the intervention, (c) test the data collection methodology and procedure, (d) increase PI's experience in conducting research as a novice researcher, and (e) improve the quality and efficiency of the main dissertation study. This summary of the pilot study addressed: (a) the procedure and preliminary data analysis used in the pilot study, (b) the feasibility and safety of the intervention, and (c) the knowledge and experiences gained by the PI by conducting the pilot study.

Procedure and Preliminary Data Analysis

With a few exceptions, the pilot study followed the procedures listed in this chapter for the main study while collecting data on three participants. The three participants were two boys

and one girl, aged 6 to 8 years, and diagnosed with ASD. The children participated in the 12-week study with all intervention and data collection activities conducted at the center. After obtaining permission to conduct the pilot study from the center's director, the PI spent 2 weeks observing the behaviors and motor skills of the three participants to better understand the behaviors of the participants and develop preliminary operational definitions of the target behaviors before initiating the pilot study. Two weeks after the observation, the PI met with the center director to schedule baseline data collection. After eight data points were collected in the baseline, data stability was achieved, and the DA intervention was implemented.

In the intervention phase, all three participants participated in the DA intervention in a group setting from 1:00 p.m. to 1:20 p.m. Then one participant stayed from 1:20 p.m. to 1:40 p.m. to play the structured activities (i.e., Jenga, Lego, hopscotch, target toss, and writing). At the same time, the other two participants went back to their daily scheduled activities. When the first participant finished, another participant came out from 1:40 p.m. to 2:00 p.m., and the last participant came out from 2:00 p.m. to 2:20 p.m. Only 15 min of activities were recorded, and five minutes were left for the transition. The intervention withdrawal phase and the second intervention phase were repeated using the same procedure as the baseline and first intervention phases.

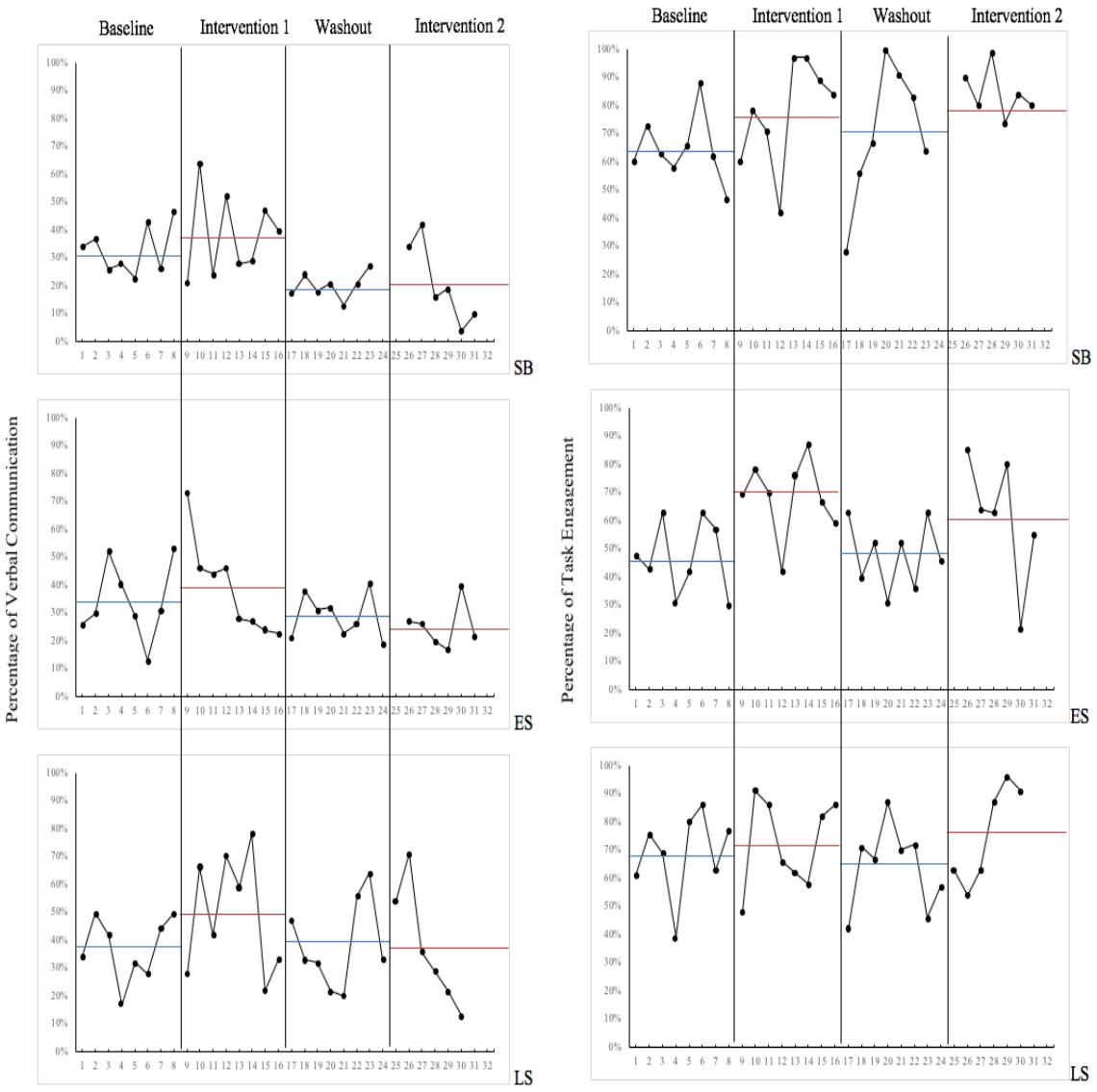
The pilot study's data analysis followed the data analysis used for the current study (discussed earlier in this chapter), which used visual analysis to analyze the 10 s partial interval recording data. Even though data analysis was conducted, the purpose of a pilot study was to assess the feasibility of the planned procedures and refine the research procedures prior to conducting the main study rather than assess the intervention's effectiveness. As such, these pilot study results were not sufficient to claim that the DA intervention was effective in improving VC

and TE for children with ASD, and the graphically depicted data is presented only to provide the preliminary results.

Visual inspection of the graphed data indicates that the average VC percentage for all participants did not change across phases, but the average percentages of TE changed across the phases and across participants. The percentages of TE were higher in the two intervention phases than the baseline and intervention withdrawal phases. After withdrawing the intervention, the TE percentages returned to baseline levels when the DA intervention was removed and increased again as the DA intervention was reintroduced (see Figures 2a and 2b).

Figure 2

VC and TE Intervals Percentages for Pilot Study Participants



(a) (b)

Feasibility and Safety of the Intervention

The pilot study met all objectives expected by the PI. The PI can claim that the pilot study results confirmed that intervention implementation and data collection plans were feasible. Improvements in TE across all three participants show the DA intervention's promise, but further

studies with more participants should be conducted to confirm the functional relationship between the DA intervention and the dependent variables of TE and VC. Moreover, the pilot study and the main study used non-invasive methods to collect data, and no injuries occurred while children participated in the intervention phases. Therefore, the PI can claim that the intervention is safe for participation by children with ASD.

Knowledge and Experiences Gained from the Pilot Study

Completing the pilot study provided valuable experiences to the PI. The PI realized from the pilot study that the participants' VCs and attentional focus are much lower than the PI had initially anticipated. Secondly, the PI learned that field research is complicated and challenging, especially when working with a vulnerable population (i.e., children with ASD). The PI quickly realized that more detailed information was needed to implement the intervention with fidelity. For example, the PI realized a plan was needed for how to respond when the participants exhibited aggressive or angry behaviors during the intervention. The PI gleaned experiences and critical insight during the data collection process and intervention implementation related to the unpredictable factors, such as variability among participants, participants' schedules, weather, and data instability (e.g., more extended intervention phases were needed due to data instability). Of critical importance, the PI realized and appreciated RBTs' impact on all intervention and data collection procedures.

Despite these challenges, all three participants successfully completed the study. From the insights provided by the completion of the pilot study, it was recommended that the current study: (a) implemented the intervention on an individual basis, rather than small group format, if the participants' schedules allowed reducing the distraction from other participants, (b) provided one initial activity for the participants to do in the 15 min data collection period to minimize the

distractions created when transitioning from one activity to another one, (c) changed the intervention and data collection environment from outdoor open-air space to a relatively closed environment (e.g., three-sided covered tent) to reduce the distraction from the environment, and (d) conducted data collection during the same 15 min interval immediately following the intervention.

Finally, the pilot study provided hands-on experiences and increased the PI's confidence in the developed research protocol. More importantly, after working with children with ASD for multiple months, the PI understood the symptoms exhibited in children with ASD and the impact of those symptoms on the intervention implementation and data collection processes.

CHAPTER IV

RESULTS

The purpose of this study was to examine the effects of the DA program, implemented as an antecedent-based intervention, on VC and TE in children with ASD. In this chapter, VC and TE responses to the DA intervention are presented in relation to the two research questions. The first research question is: Implemented as an antecedent-based intervention, does DA intervention improve VC in children with ASD? The second research question is: Implemented as an antecedent-based intervention, does DA intervention improve TE in children with ASD? Within this study, VC was measured when the participants were able to: (a) respond to the PI's and RBTs' questions verbally, (b) ask for help verbally, and (c) initiate a verbal conversation with the PI or the RBTs. TE was measured when the participants were able to: (a) stay engaged in assigned activities, (b) work on assigned activities, and (c) use the activity materials. This chapter presents the findings in the following order: (a) descriptive and performance information for individual participants, (b) information on group performances, (c) inter-observer reliability, (d) fidelity (e) social validity, and (f) summary.

Descriptive and Performance Information for Individual Participants

Oliver

Verbal Communication

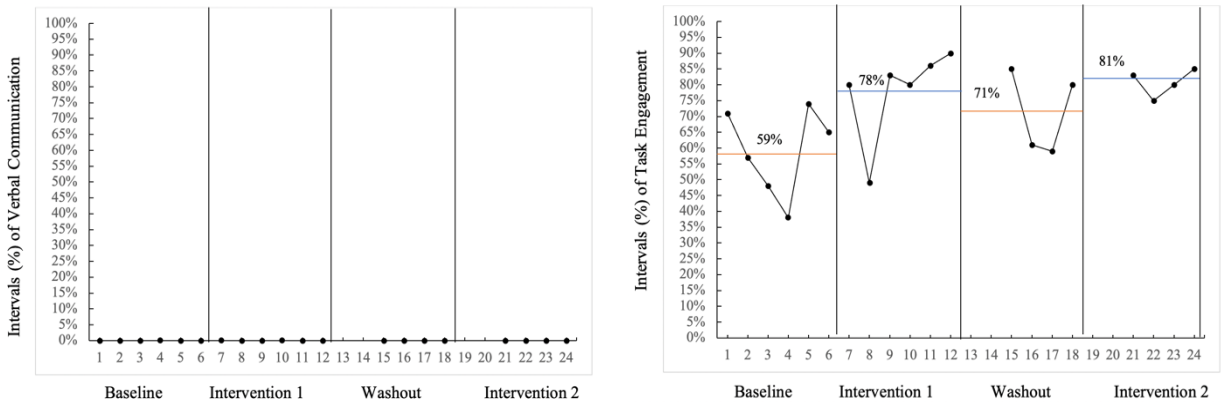
Though Oliver met the inclusion criteria, he had very limited expressive language. During the baseline phase, Oliver demonstrated no VC. This pattern of no VC continued across both intervention phases and the washout phase, resulting in no observable VC for Oliver during the 2-month study (see Figure 3a).

Task Engagement

During baseline, Oliver's average percentage of TE was 59% (range = 38–74%). After the first DA intervention, Oliver's TE increased from 59 to 78% (range = 49–90%). With the withdrawal of the DA intervention during the washout phase, Oliver's TE decreased to 71%, with a range of 59–85%. His TE level during the second DA intervention phase increased from 78% in the first intervention phase to a mean of 81%, with a range of 75–85%. Here, the highest level of TE was observed with a concomitant lowest level of variability versus all other phases. Interestingly, in both intervention phases, after an immediate decrease in the first data point, the percentage of TE steadily increased (see Figure 3b).

Figure 3

VC and TE Intervals Percentages for Oliver



(a) (b)

Two data points were not recorded during the washout and the second intervention phase because Oliver was absent due to illness. In terms of data variability, bigger variabilities were observed in the baseline and washout phases, while the data were more stable in the two intervention phases. Regarding the latency of the TE behavior, the TE increased immediately after introducing the intervention. In summary, Oliver's TE increased after both DA

interventions. Therefore, the hypothesis that there would be an observed improvement of TE in participants following the antecedent DA intervention was accepted.

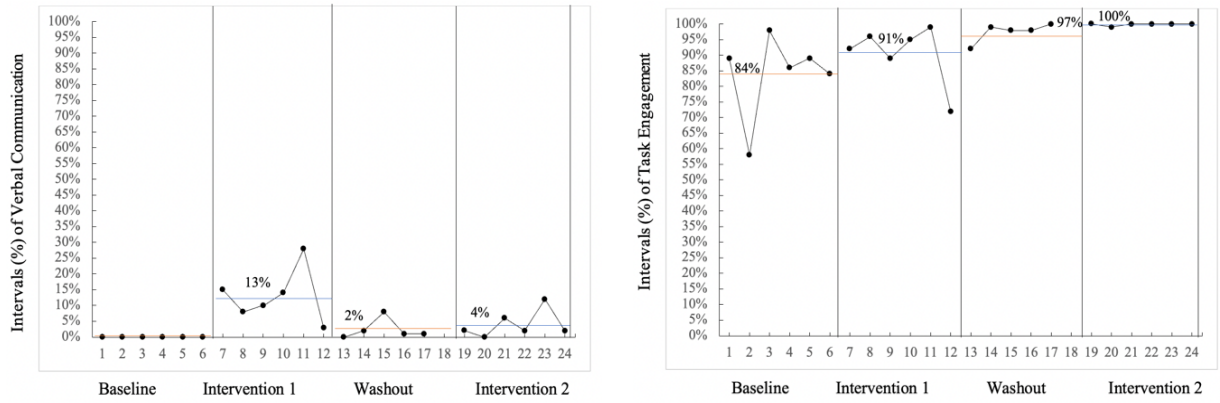
Ethan

Verbal Communication

Similar to Oliver, Ethan did not demonstrate VC in the baseline phase. However, after introducing the first intervention, Ethan demonstrated the use of single words (e.g., help, go, yes) in response to questions. His VC increased to 13% (range = 3–28%) during the first intervention phase but decreased to 2% after withdrawal of the intervention (range = 0–8%). Although the VC increased to 4% (range = 0–12%) in the second intervention phase, his frequency of VC was still low. In summary, after introducing the DA intervention, Ethan increased his use of single-word responses for communication. However, this VC decreased to near baseline levels after the withdrawal of the intervention (see Figure 4a).

Figure 4

VC and TE Intervals Percentages for Ethan



(a) (b)

Task Engagement

In the baseline phase, Ethan's percentage of TE was 84% (range = 58–98%). During the first DA intervention, Ethan's TE increased from 84 to 91% (range = 72–99%); this TE was

maintained in the washout and second intervention phases. In the second DA intervention phase, the highest level of TE was observed with a concomitant lowest level of variability versus all other phases. Except for the first and the 12th data points, Ethan's TE was very stable. Although Ethan maintained a high level of TE and complied with the RBT's request to do all tasks, his overall ability to correctly complete tasks was low. In summary, Ethan's TE was increased and maintained after the DA intervention (see Figure 4b).

Dylan

Verbal Communication

Overall, Dylan's VC was stable across all four phases, with self-talk being the predominant form of VC. When responding to the RBTs or PI, Dylan's VC answered questions in one or two-word phrases, such as responding that the color of the Jenga block was "yellow." Dylan did not initiate a conversation with his RBTs or the PI. Specific to the phases of the study, Dylan demonstrated a higher percentage of VC in the baseline (M = 16%, range = 2–34%) and washout phases (M = 14%, range = 0–30%) when compared to both intervention phases (M = 10%, range_{DA1} = 2–13%, range_{DA2} = 4–21%). Therefore, the DA intervention did not increase VC for Dylan (see Figure 5a).

Task Engagement

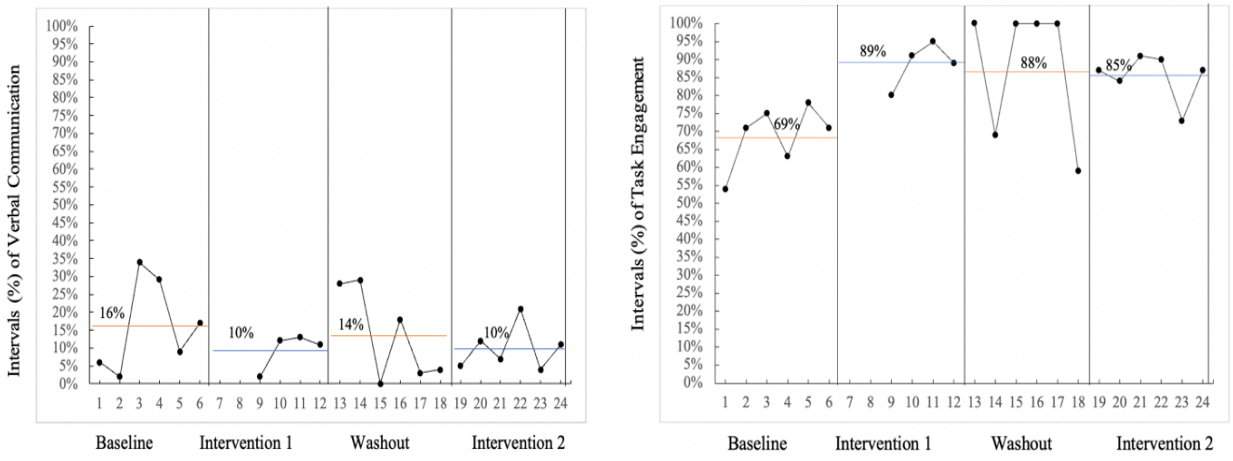
During baseline, Dylan's percentage of TE was 69% (range = 54–78%). After the first DA intervention, Dylan's TE increased 20% from 69 to 89% (range = 80–95%). His TE was maintained at 88% (range = 59–100%) in the washout phase and decreased slightly to 85% (range = 73–91%) after the second DA intervention. It should be noted that as can be seen from a visual inspection of Dylan's data, a high level of variability existed in data points across all four phases. Given that the TE did not improve in the second intervention phase like the first

intervention phase as hypothesized, it cannot be concluded that the DA intervention effectively increased TE for Dylan (see Figure 5b).

In addition, both the VC and TE data for Dylan have a high level of variability. For example, despite the four TE data points of 100% in the washout phase, the TE mean for the washout phase was 88% (range of 59–100%) due to two considerably lower data points (i.e., the 13th and 18th data points). Regarding the data trend, there was not a significant change in VC across all four phases nor was there a substantial change in TE in the last three phases. Still, there was a significant (20%) increasing trend between the baseline and first intervention phase (see Figure 5).

Figure 5

VC and TE Intervals Percentages for Dylan



(a) (b)

Jesus

Verbal Communication

Jesus demonstrated higher VC in all phases when compared to all other participants. For example, Jesus answered the RBTs' questions correctly with multiple-word responses and initiated conversations with the RBTs and PI. Upon visual inspection, Jesus's VC was similar in

the baseline phase and first intervention phase ($M_{Baseline}$ = 54%, range = 40–72%; M_{DA1} = 53%, range = 40–61%). Interestingly his VC increased to 67% (range = 38–77%) in the washout phase but dropped back to 43% (range = 31–53%) in the second intervention phase. Therefore, it can be concluded that the DA intervention did not effectively improve VC for Jesus.

Furthermore, although he demonstrated a high percentage of VC, it should be noted that much of Jesus's VC was repetitive echolalia speech, including self-talk, rather than interpersonal communication with the RBT or PI. The repetitive echolalia speech contributed significantly to Jesus's high VC data (see Figure 6a).

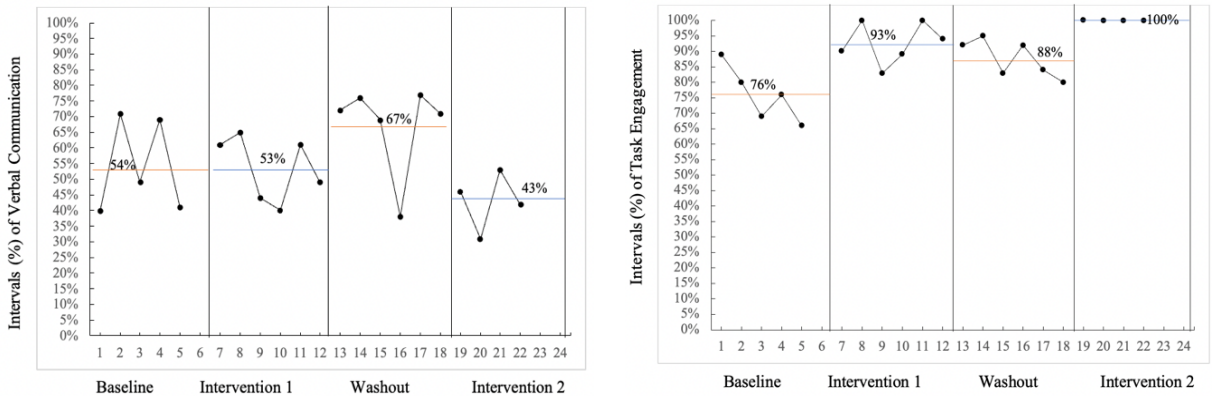
Task Engagement

In the baseline phase, Jesus's TE was 76% (range = 66–89%), which increased to 93% (range = 83–100%) during the first intervention phase. After withdrawing the intervention in the washout phase, Jesus's percentage of TE decreased to 88%, with a range of 80–95%. Interestingly, although Jesus was quite physically active while participating, he demonstrated 100% TE during the second intervention phase. In the second intervention phase, the highest level of TE was observed with a concomitant lowest level of variability versus all other phases. It should be noted that, though there was stability in the data points, Jesus was absent for 2 days during the second intervention resulting in four rather than six data points in this phase. As presented in Figure 6b, the percentage of TE in both intervention phases is approximately 15% higher than in the baseline and washout phases. As such, the DA intervention seemed to have a significant impact on Jesus's TE. It should also be noted that observations from the intervention video and field notes document not only Jesus's high level of engagement but also his enjoyment of the drumming activities (e.g., he always requested to play more DA activities when we

completed the DA sessions; and after withdrawing the DA intervention, he often asked where the drumming ball was).

Figure 6

VC and TE Intervals Percentages for Jesus



(a) (b)

Elijah

Verbal Communication

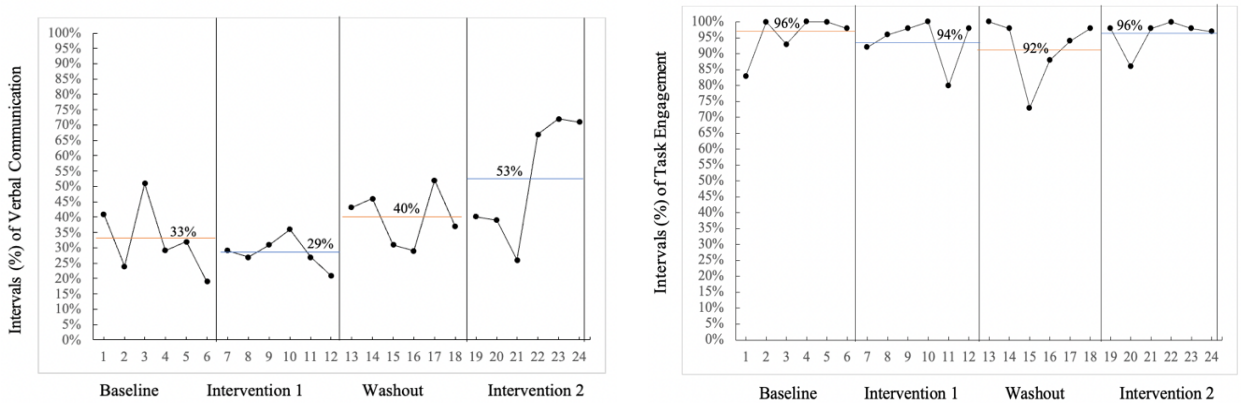
Elijah demonstrated a relatively high percentage of VC. His VC decreased from 33% (range = 19–51%) at the baseline phase to 29% (range = 21–36%) during the first intervention phase. Elijah's VC then increased to 40% (range = 29–52%) during the washout phase and increased to 53% (range = 26–72%) during the second intervention. The high variability in Elijah's VC data may be due to the fluctuations in his social behaviors (e.g., some days he was very active and asked many questions while other days he was reticent and did not respond to the RBTs questions). Given that Elijah's VC decreased after the first intervention was introduced, it cannot be concluded that the DA intervention effectively increased VC for Elijah (see Figure 7a).

Task Engagement

Elijah completed all the tasks independently and completed most tasks correctly (e.g., when participating in the Jenga activity, Elijah stacked all Jenga blocks in the correct pattern and took turns with the RBT pulling one Jenga block out at a time). He did, however, complete some tasks differently than initially instructed by the RBT (e.g., when asked to dance following a specific movement sequence, he danced in his own way rather than following the movement sequence). His percentage of TE at baseline was very high (M = 96%, range = 83–100%) and was maintained at a high and stable level across all four phases, with an average of 94% (range = 73– 00%) across all phases. Interestingly, as presented in Figure 7b, there was one data point in each phase that was very low compared with all other data points in the phase. Those data reflected the considerable changes in Elijah's behavior that occurred once during each of the four phases, which lowered the average percentage of TE for each phase. The lack of improvement in TE for Elijah may be attributed to a ceiling effect as his engagement was near 100% across all four phases (see Figure 7b).

Figure 7

VC and TE Intervals Percentages for Elijah



(a) (b)

Information on Group Performances

Verbal Communication

Based on the visual analysis, there were individual differences among each participant. Oliver did not demonstrate any VC or changes in VC in any of the four phases, while Ethan increased his use of single-word responses during the first intervention. Dylan demonstrated increases in single-word responses but did not independently initiate a conversation. Jesus and Elijah had higher VC when compared to other participants, but still demonstrated social communication deficits including repetitive echolalia speech and self-talk. Based on VC data for all five participants, the hypothesis that a higher VC percentage would be observed in the two intervention phases compared to the baseline and washout phases is not supported. There was no specific trend or pattern in the VC data for the five participants across all four phases of the study. However, consistent with the etiology of ASD, deficits in social communication were observed across all participants (see Table 12 and Figure 8).

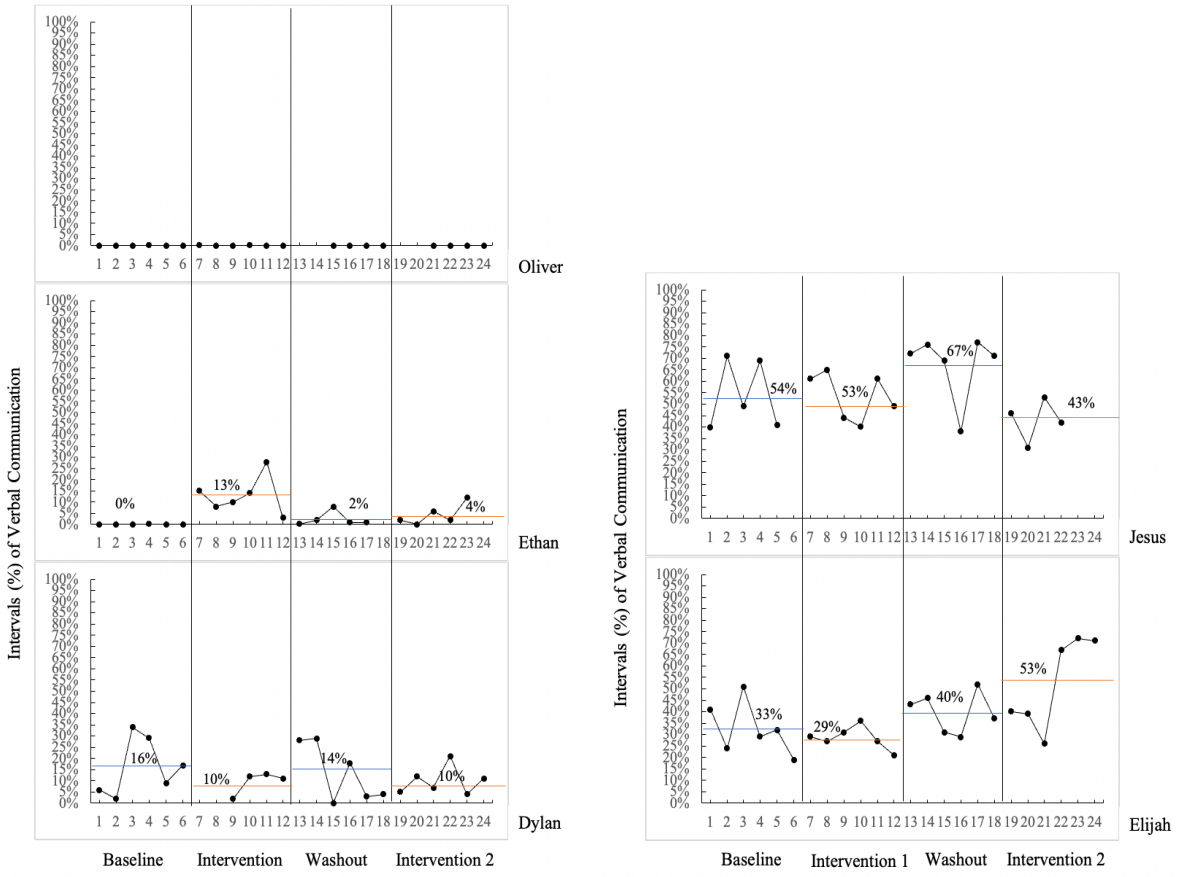
Table 12

Means for VC for Participants Across Phases

Participants	Baseline	Intervention 1	Washout	Intervention 2
Oliver	0%	0%	0%	0%
Ethan	0%	13%	2%	4%
Dylan	16%	10%	14%	10%
Jesus	54%	53%	67%	43%
Elijah	33%	29%	40%	53%

Figure 8

All Participants' VC Intervals Percentage



Task Engagement

The mean percentage of TE for all five participants was 77% in the baseline, 89% in the first intervention phase, 87% in the washout phase, and 92% in the second intervention phase. Apart from Elijah, whose data documented a ceiling effect, the hypothesis that there would be an increase in TE during the two intervention phases compared to the baseline and washout was accepted. Oliver, who demonstrated the lowest initial TE among all participants, had a large increase in TE after the DA intervention. His TE increased by 20% during the first intervention when compared to the baseline and increased by 10% during the second intervention when compared to the washout phase. Ethan demonstrated increases in the first intervention phase

when compared to baseline, but his TE did not substantially change during the other two phases. Elijah's TE at the baseline was already as high as 96%, and there was little room for improvement. While there were no obvious increases in the two intervention and washout phases, both Ethan and Elijah's TE were maintained at a high level with an average of 95% (see Figure 9 and Table 13).

Figure 9

All Participants' TE Intervals Percentage

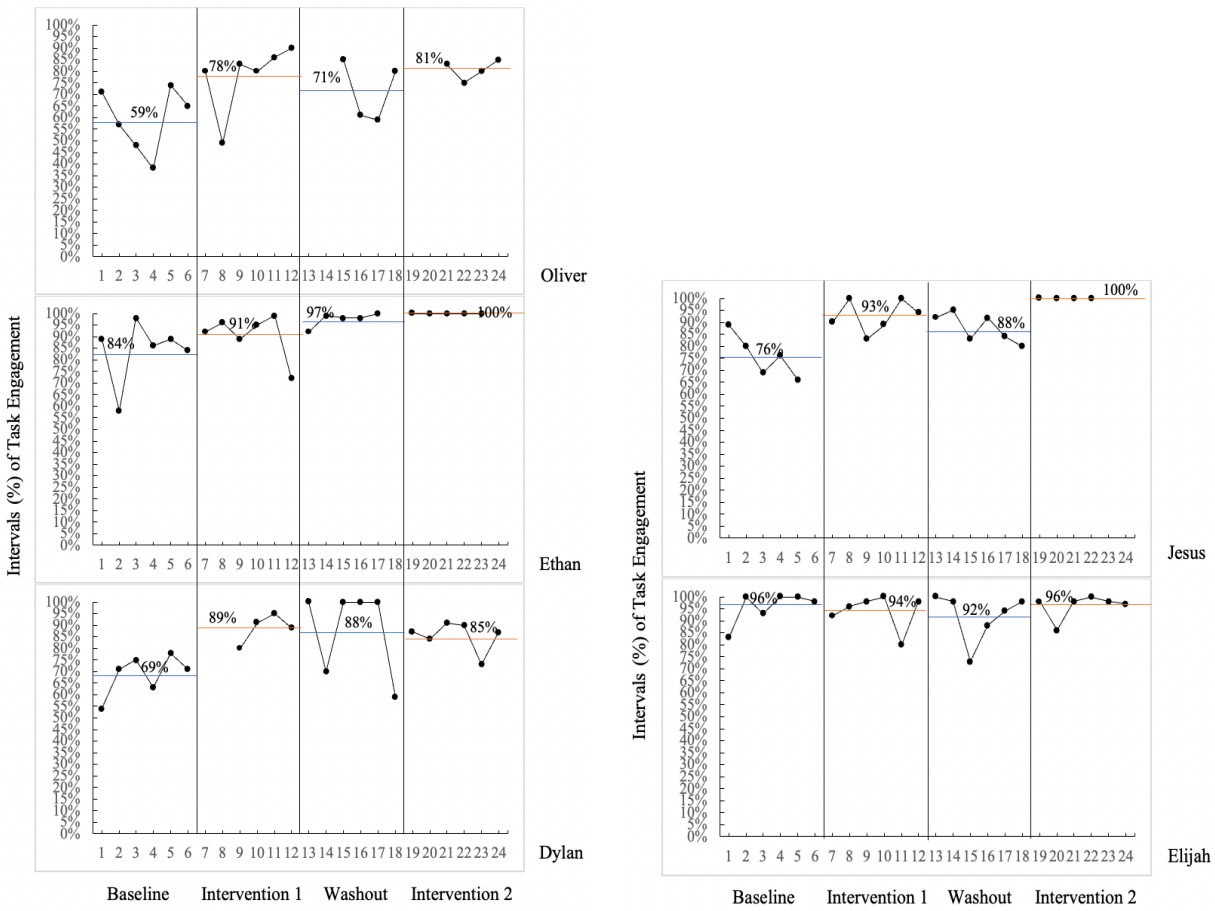


Table 13

Means for TE for Participants Across Phases

Participants	Baseline	Intervention 1	Washout	Intervention 2
Oliver	59%	78%	71%	81%
Ethan	84%	91%	97%	100%
Dylan	69%	89%	88%	85%
Jesus	76%	93%	88%	100%
Elijah	96%	94%	92%	96%

Inter-Observer Reliability

A second observer, who holds a doctorate in adapted physical activity, was involved in coding data for checking the inter-observer reliability (IOR). The IOR for TE and VC was obtained for at least 50% of sessions for each participant. These sessions were randomly distributed across the baseline, washout, and two intervention phases. The percentage of IOR was calculated by dividing the number of agreements intervals by the total 90 intervals then multiplying that score by 100%. The percentage of IOR between the PI and the second observer for the VC was 86% (range = 80–89%), and for the TE was 83% (range = 80–85%).

Fidelity

Two fidelity checklists (see Appendix G) were used to determine the data collection procedure fidelity and the intervention procedure fidelity. Procedural fidelity data were collected across at least 30% of baseline, interventions, and washout sessions (i.e., 35% for baseline, 40% for interventions phases, 30% for washout) to ensure that all the necessary data collection and intervention procedures were implemented as planned. The participants' RBTs were asked

whether the PI completed each necessary step based on the fidelity checklist. The data collection procedure fidelity checklist included five items (e.g., the PI presented one activity at a time and asked the participants to change activity every 5 minutes). The intervention procedure fidelity checklist included five items (e.g., the PI always started the intervention with warm-up activities and end the intervention with cool-down activities). The percentage of fidelity was calculated by the number of accurately implemented steps divided by the total number of steps and multiplied by 100%. The data collection procedure's average percentage fidelity was 95% (range = 90–100%) for the baseline, 94% (range = 92–100%) for both intervention phases, and 92% (range = 90–100%) for the washout phase. The intervention procedure average percentage fidelity was 94% (range = 92–98%) for the first intervention phase and 96% (range = 93–98%) for the second intervention phase. In summary, both the data collection procedure and the intervention procedure obtained a high percentage of fidelity, which means all steps were implemented as planned.

Social Validity

In addition to the fidelity checklists, each participant's RBT completed the social validity questionnaire (see Appendix H). The overall mean score across the five RBTs was 4.83 out of 5 (i.e., 1 = *strongly disagree*, 5 = *strongly agree*). Two of the RBTs strongly agreed with all questions ($M = 5$, range = 5–5), and other RBTs answered all questions positively with a mean score of 4.5 (range = 3–5). All the RBTs indicated that the DA intervention was appropriate and effective for their clients, and there were no adverse effects to participating in the DA intervention. Also, they reported that the intervention activities were easy to follow and age-appropriate. At the end of the data collection, they agreed that the DA intervention was

cost-effective, and they were willing to implement the intervention with other children with ASD after the conclusion of this study. All RBTs responded positively in terms of the social validity of the DA intervention. Furthermore, three of five participants regularly verbalized enjoying the DA activities. Though Oliver and Ethan did not verbally express their enjoyment, their RBT indicated they demonstrated excitement when they were told it was time for the DA activities.

Summary

Based on the visual analysis of the means percentage for the individual performance, Oliver demonstrated no VC or changes in VC during the study period, but he demonstrated the greatest increases in TE. Ethan had no VC in the baseline phases but had single-word responses after introducing the DA intervention. Although Ethan's VC decreased to near zero in the washout and second intervention phase ($M_{Washout}$ = 4%, M_{DA2} = 2%), he did demonstrate an increase in VC from baseline. Ethan's TE had a substantial increase from baseline to the first intervention phase and was maintained at a high and stable level across the last three phases. Dylan's VC frequency was higher than Oliver and Ethan's, and it was maintained at a relatively low and stable level (M = 12%, range = 10–16%) across the study period. Regarding Dylan's TE, he demonstrated a 20% increase from the baseline to the first intervention phase, which was maintained across the remaining phases. Jesus and Elijah had relatively higher percentages of both VC (M_{Jesus} = 54%, $\text{range}_{\text{Jesus}}$ = 43–67%; M_{Elijah} = 39%, $\text{range}_{\text{Elijah}}$ = 29–53%) and TE (M_{Jesus} = 89%, $\text{range}_{\text{Jesus}}$ = 76–100%; M_{Elijah} = 95%, $\text{range}_{\text{Elijah}}$ = 92–96%) compared to the other three participants.

Regarding the group's VC across all four phases, it was determined that the DA intervention was not effective in increasing participants' VC. There was significant VC variability among the five participants, and all five participants demonstrated limited social

communication as anticipated with the participants' diagnosis of ASD. Regarding the mean percentage for group TE across all four phases, it was determined that the DA intervention effectively increased participants' TE. Except for Elijah, all participants demonstrated increases in TE during the intervention phases versus the baseline and washout phases.

CHAPTER V

DISCUSSION

The purpose of this study was to examine the effects of the DA program, implemented as an antecedent-based intervention, on VC and TE in five children with ASD. The DA program emphasizes moving in various rhythmic patterns to the beat of the music using whole-body movements, hands clapping, and drumsticks clicking (Wellemin et al., 2018). The DA program allows for an easily implemented multimodal and multisensory intervention, which has been shown to be effective in improving the physical and motor skill performance of children with developmental disabilities, including those with ASD (Ekins et al., 2021). The current study applied an ABAB intervention withdrawal single-subject design allowing the researcher to make strong conclusions regarding the DA effects by introducing the DA intervention twice in different phases. Guided by the results of this study, the chapter is organized and presented as follows: (a) discussion of the findings specific to each research question, (b) implications for practice and future research, (c) limitations of the current study, and (d) concluding comments.

Discussion of Findings Specific to Each Research Question

Research Question 1

This study was designed to investigate two research questions. Research Question 1 sought to determine whether DA, implemented as an antecedent-based intervention, would improve VC in children with ASD. After partaking in the DA intervention, the group of participants demonstrated no improvement in the overall mean percentage values of VC. Additionally, individually, no participant demonstrated an improvement in VC across both intervention phases. However, one participant (i.e., Ethan) increased VC, expressed as single-word communications, during the first intervention phase.

Communication deficits are one of the diagnostic criteria for ASD (APA, 2013). As a result, developing communication and language skills is a significant long-term goal for most training programs for children with ASD (Lim, 2009; Paul, 2008). Based on the premise that the DA program, which is a form of PA that combines music, rhythmic movement, and drumming, has a significant amount of auditor-motor integration, it was hypothesized that the DA program would improve the VC among the participating children with ASD. Auditory-motor integration is critical for acquiring complex social interaction and communication skills, such as speech and language (Tryfon et al., 2017; Zatorre et al., 2007). However, no improvement in VC was observed among the participants. This result is consistent with the research of Howells et al. (2019), who examined the effects of PA on social outcomes among children with ASD and reported a non-significant effect on communication. As an intervention, music has been proven to be effective in improving language development (e.g., Kaplan & Steele, 2005; Lim, 2010; Wan et al., 2010), but has not been shown effective in increasing the initiation or engagement in communication for individuals with ASD. Preis et al. (2016) documented that the presentation of music in the background was not sufficient to affect the spontaneous verbal expression or verbal engagement in five young participants with ASD. Additionally, LaGasse (2014) reported that music therapy as a group intervention has no impact on communication initiation and response to communication. Finally, the observed variability in treatment responses for VC may be accounted for by the nature of ASD and the high degree of variability in the population (Wozniak et al., 2017). Therefore, it is not surprising to see no improvement in VC in a short-term intervention, such as the DA intervention implemented in the current study.

Research Question 2

Research Question 2 sought to determine whether DA, implemented as an antecedent-based intervention would improve TE in children with ASD. Unlike VC, increases were observed in TE for the children with ASD following participation in the DA intervention. The overall mean percentages of TE for all five participants were higher after the two intervention phases versus the baseline and washout phases. Additionally, all participants except Elijah experienced individual post-intervention improvements in TE during the first and second DA intervention phases. The observed increase in TE in the current study resulting from participation in the DA intervention may be explained by the design of the DA intervention, which combines PA, music, rhythmic movement, and percussion. The cumulative impact of these DA program elements may contribute to the finding of increased TE as each element is believed to stimulate the frontal lobe of the brain (e.g., De Vries et al., 2015; Ji et al., 2019; Ragone et al., 2021).

The frontal lobe of the brain is the segment of the brain that constitutes two-thirds of the human brain, which performs the functions of memory, motor, language, and attention (Chayer & Freedman, 2001; Collins & Koechlin, 2012). For example, frontal lobe lesions, especially of the right hemisphere, have been shown to cause deficits of sustained attention, which is related to the ability to maintain attention over a prolonged period (Rueckert & Grafman, 1998). Given the relevance of the frontal lobe to attention, conditions that are associated with the increased functionality of the frontal lobe could be associated with improved TE. The prefrontal cortex, which is a part of the frontal lobe and mediates working memory and decision-making, has also been found to be highly associated with attention (Rossi et al., 2009). Interestingly, the major

elements of DA (i.e., PA, music, rhythmic movement, and percussion) are all associated with enhanced prefrontal cortex activity.

Physical Activity and Task Engagement

The DA program is designed centrally around PA, which has been found to be associated with improved prefrontal cortex activity (Ji et al., 2019). As previously noted, the prefrontal cortex activity plays a critical role in one's ability to switch attentional control based on changing task demands (Rossi et al., 2009). In their systematic literature review, Lang et al. (2010) concluded that PA interventions were effective at significantly reducing off-task behaviors in individuals with ASD. For example, Miramontez and Schwartz (2016) compared the effects of yoga, dance, and book reading on on-task behavior for children with ASD who were engaged in journal writing following each intervention. The researchers purported that PA before writing led to higher levels of on-task behavior during journal writing although the design of this study did not allow for the establishment of causation. Other researchers have established an association between PA and prefrontal cortex activity (Tsujii et al., 2013). Therefore, it is plausible to speculate that the PA component of the DA contributes to increased prefrontal cortex activity, which could be associated with the observed increases in TE in the current study.

Music and Task Engagement

The DA program's design includes music, which has also been found to be associated with prefrontal cortex activity (De Vries & Geurts, 2015). Researchers have reported that musical improvisation and instrument playing, which have been implemented as interventions for individuals with ASD, affect executive function and attention (Koshimori & Thaut, 2019). It is no wonder that music is included in interventions for individuals with ASD, given that individuals with ASD often have similar or superior music processing skills when compared to

their typically developing counterparts (Bacon et al., 2020) and that music intervention is associated with improvements in executive function and attention. In their systematic review of the effect of music intervention on the traits and executive functioning of individuals with ASD, De Vries et al. (2015) reported that the benefits of music intervention included, but were not limited, to increasing attention to tasks. Similarly, the work of Baker (2019), conducted at Stanford University's School of Medicine, documented that listening to music activates the prefrontal cortical areas, which support executive functioning and attention focus. A year later, Kasuya-Ueba et al. (2020) compared the effects of music interventions and video game intervention on the attention of children and found music to be more effective than video games in improving attention control. Given that the DA intervention integrates music, and that music is associated with increased frontal lobe and prefrontal cortex activity, which are associated with increases in executive function and attention, it is not surprising that TE increased following the DA intervention.

Rhythmic Movements and Task Engagement

Beyond just general PA, specific rhythmic movements are a major component of DA. Relevant to the current study, rhythmic movement has been shown to increase TE when children with ASD continuously generate sounds through rhythmic body movements (Ragone et al., 2021). Rhythmic movements typically involve whole-body movements that connect the human sensory and motor systems. This connection is called temporal rhythmic entrainment, which has been researched by Thaut and colleagues (e.g., Thaut & Abiru, 2010; Thaut et al., 2015) and successfully extended into applications in cognitive, speech, language, and motor rehabilitation. Research establishing the significant neurological mechanisms that link music and rhythm to brain rehabilitation served to guide the design of this study and support the current findings of

increased TE following the DA intervention. In her 2018 review of literature specific to coordinated rhythmic movement activities in younger children, Williams (2018) provided evidence that rhythmic activities in preschool are a practical approach to supporting neurological bases of self-regulation, such as regulation of attention. Further, Benson et al. (2020) suggested that providing sensorimotor strategies embedded within classroom activities, such as rhythmic movement, allows for improved self-modulation and classroom participation including attention for students with ASD, and established an association between rhythmic movement and attention. Therefore, it is reasonable to speculate that the rhythmic movement component of the DA could be responsible in part for the improvement in TE observed in the current study.

Many consider the percussion element of DA to be one of the most significant elements of DA. It has been suggested that playing a percussion instrument can enhance the function of the prefrontal cortex (Shimizu et al., 2018). In general, the DA rocking drumming activities, which combine percussive and rhythmic movements, are more physically demanding than playing other musical instruments and offer a viable alternative to other moderate to high-intensity PA. Specifically, rocking drumming activities require the gross motor coordination of all four limbs to create independent actions on a separate element of the drum kit/fit ball. Lowry et al. (2019) investigated the effect of rocking drumming on the psychosocial skills of children with emotional and behavioral disturbances. The researchers indicated that a reduction in hyperactivity and social problems with peers were evident following the 5 weeks rocking drumming intervention. In a related study, Su et al. (2020) implemented a 6 months taiko drumming program for students with learning disabilities and found that the drumming lesson improved the attention and social interaction skills of students with learning disabilities.

Summary of Improvement on Task Engagement

One major finding of the current study was that the DA intervention was associated with improved TE as a group and on an individual basis. The design of the study did not allow the establishment of causality; therefore, the claim cannot be made that the DA intervention caused the observed increases in TE. However, given the association between attention and the elements of the DA intervention, it is plausible to speculate that each element of DA could have contributed to the changes in TE and that collectively the elements could have had a combined effect on the finding of increased TE after the DA intervention. While Elijah did not demonstrate significant increases in TE over the four phases of the study, his level of TE was very high (96%) in the baseline phase and this high level of TE was maintained in all phases. Given this ceiling effect, there was little opportunity for Elijah to increase his TE.

Implications for Practice and Future Research

While children with ASD face many challenges, perhaps two of the most critical challenges are VC (APA, 2013) and TE (Ashburner et al., 2008; Richler et al., 2010). These challenges are significant because they impact individuals' participation in school as well as their ability to function in society as adults (De Vries & Geurts, 2015). Because these challenges could influence the individual over their lifespan, it is essential to intervene as early as possible. Researchers have documented the positive and significant effects of early intervention for children with ASD (e.g., Corsello, 2005; Williams, 2018). While medication is one intervention commonly used with children with ASD, most efficacious medications do not directly address these VC and TE challenges and often come with many undesirable side effects (Baribeau & Anagnostou, 2014). Given the relevance of addressing VC and TE in children with ASD and the concomitant side effects of medication, there is an urgent need to find new and dynamic ways of

addressing these challenges, particularly within the school context. One such intervention is the use of PA, which has been shown to impact both VC (Howells et al., 2019) and TE (Ferreira et al., 2019; Lee et al., 2018; Miramontez & Schwartz, 2016; Nakutin & Gutierrez, 2019; Neely et al., 2015; Nicholson et al., 2011; Oriel et al., 2011; Pokorki et al., 2019; Wang et al., 2020).

Many children with ASD may not be very enthusiastic and may not enjoy participating in PA (Hauck et al., 2014; Jachyra et al., 2021). In addition, it is challenging for children with ASD to engage in PA for a prolonged period due to delayed motor skills (Berkeley et al., 2001; Green et al., 2009; MacDonald et al., 2013; Staples & Reid, 2010). Therefore, there is a great need for researchers and practitioners to develop PA interventions that require lower motor skills from participants and that might be compelling to children with ASD. The DA program holds promise as an intervention as it has been particularly attractive to children with ASD and it integrates elements of PA with rhythmic movement and music, as both have been shown to increase interest and adherence to PA (De Vries et al., 2015; Hardy & LaGasse, 2013; Shi et al., 2016). Given the findings of this study, it is plausible to assume that the DA program could be used by practitioners to increase TE for children with ASD.

Current trends in ASD research indicate that increased use of multi-sensory interventions would strongly impact the core symptoms of ASD (Unwin et al., 2021). Prior research on the DA programs has shown to be effective in helping children develop motor skills, executive functions, attention, and behavior control (e.g., Ekins et al., 2021; Willemin et al., 2018; Yoo & Kim, 2016). The findings of this study have direct implications for clinical practice as the DA program effectively increased TE. Even participants with poor motor skills were able to participate in the DA program because of its simple movements, such as bouncing on the ball, rolling on the ball, or running around the ball and drumming. Therefore, the DA program should be introduced to

more educators and clinical professionals and considered for implementation in professional practice. Given that the current study is only one of a limited number of research studies focused on examining the DA effect on VC and TE in children with ASD, more research is needed to fully understand the functional relationship between the DA program and VC and TE. Such understanding could provide valuable clinical information on the use of DA as an early intervention addressing the core symptoms of ASD.

Future studies that seek to investigate the effectiveness of DA should include collecting follow-up data to assess the maintenance of improvements over time. In addition, future research should widen the range of dependent variables measured such as motor skills, PA level, and mood change. For example, it could be beneficial for practitioners and parents if researchers examined the overall impact of the DA intervention, including variables more closely associated with mood and other behaviors. If combined with qualitative inquires, such as interviews with participants' RBTs, teachers, and/or parents regarding the participants' overall performance in the clinical setting and at home, mixed methods research could also enhance the understanding of perceived benefits of participation in the DA program. Future research could also consider including parents in the DA intervention and/or inviting them to facilitate DA programming at home. Further research is also needed to investigate the quality of the post-intervention activities as well as variations to the intensity, duration, and frequency of the DA intervention.

Limitations

Several limitations require attention when interpreting the results. There are many potential internal and external factors that could have impacted the results of this research. The limitations include sample size, participants selection, setting environment, data collection, and measures on VC and TE. For example, the sample was selected as a convenience sample, and the

five male participants may not be representative of the larger population due to their unique characteristics; hence, the findings are less generalizable.

The current study also did not examine changes in PA levels or motor skill level as a dependent variable. In addition, claims cannot be made about the intervention intensity of specific participants without direct measurement. The original design considered using a heart rate monitor to track participants' heart rate during the DA intervention. However, the wearable device was removed from the study design based on the findings of the pilot study, as the wearable technology significantly distracted the participants thus preventing them from engaging in the DA activities. More methods should be explored to measure the intervention intensity as it may be key to changes in TE and VC.

This study's ABAB intervention withdrawal single-subject design cannot rule out the possible effect of maturation and curriculum of the therapeutic day program in which the children in this study were enrolled. For example, it was revealed that Oliver received speech therapy services at the same time the current study was being conducted. While these speech therapy services were delivered during the day program, and not within the DA intervention sessions, they did hold potential to impact the findings.

Additionally, defining and measuring TE within single-subject research can be challenging. This study applied a behavioral definition of engagement, which may have under-estimated engagement levels across different participants. For example, in the hopscotch activity, some participants chose a preferred locomotor pattern other than the locomotor pattern requested by the RBT to complete the hopscotch course. Using the operational definition for TE, that behavior of engaging in a locomotor pattern other than the locomotor pattern requested was coded as not engaged in the task. There were multiple examples of similar situations where the

participants were involved in an activity but not in the specifically requested task. A pilot study was used to improve the operational definition of TE and the measurement process, but additional research could be used to further improve the measurement of TE.

Lastly, the current study used the partial interval coding method to code the TE variable. In the partial interval coding, if the participant is on-task at all during the partial interval (even for one second), that interval should be coded as engaging in the task. However, the reality is that during the 10-s interval, the participant could have been off-task for as long as 9 s. Therefore, the results of this study should be considered in light of the selected coding methodology.

Conclusion

For the participants in the current study, increases were observed in TE but not in VC. Although the attrition rate was zero, multiple factors could have affected the functional relationship between the DA intervention and observed behaviors of VC and TE. The current study contained several strengths including the withdrawal intervention design, which allowed the participants to act as their controls. In addition, the randomization of the post-intervention activities was used to reduce the threats to external validity. While some caution is warranted in generalizing these results, this study supports the use of the DA as a multi-sensory antecedent-based intervention, inclusive of PA, musical, rhythmic movement, and percussion elements, to facilitate TE in post-intervention activities for children with ASD. DA appears to be a powerful, motivating, and creative medium for many children and adults (Ekins & Owens, 2018; Ekins et al., 2021; Ekins et al., 2019; Knappová et al., 2013; Yang et al., 2021). Continuing to explore the effect of DA and similar programs (e.g., Ability Beats, Drumtastic, DrumFit) on active engagement could improve learning environments and learning outcomes for

individuals with ASD. The present study confirms previous findings and contributes additional evidence that the DA intervention can improve TE for children with ASD.

REFERENCES

Antshel, K. M., & Russo, N. (2019). Autism spectrum disorders and ADHD: Overlapping phenomenology, diagnostic issues, and treatment considerations. *Current Psychiatry Reports*, *21*(5). https://doi.org/10.1007/s11920-019-1020-5

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Washington, DC: American Psychiatric Association.

Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy*, *62(*5), 564-573.

Autism Focused Intervention Resources & Modules. (2016). *Antecedent-Based Intervention*. https://afirm.fpg.unc.edu/antecedent-based-intervention

Bacon, A., Beaman, C. P., & Liu, F. (2020). An exploratory study of imagining sounds and "hearing" music in autism. *Journal of Autism and Developmental Disorders*, *50*(4), 1123–1132. https://doi.org/10.1007/s10803-019-04346-w

Bahrami, F., Movahedi, A., Marandi, S. M., & Abedi, A. (2012). Kata techniques training consistently decreases stereotypy in children with autism spectrum disorder. *Research in Developmental Disabilities*, *33*(4), 1183–1193. https://doi.org/10.1016/j.ridd.2012.01.018

Bahrami, F., Movahedi, A., Marandi, S. M., & Sorensen, C. (2016). The effect of Karate techniques training on communication deficit of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *46*(3), 978–986. https://doi.org/10.1007/s10803-015-2643-y

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., Kurzius-Spencer, M., Zahorodny, W., Rosenberg, C.R., White, T., Durkin, M.S., Imm, P., Nikolaou, L., Yeargin-Allsopp, M., Lee, L.C., Harrington, R., Lopez, M., Fitzgerald, R.T., Hewitt, A., ... & Dowling, N. F. (2018). Prevalence of autism spectrum disorder among children aged 8 years—autism and developmental disabilities monitoring network, 11 sites, United States, 2014. *MMWR Surveillance Summaries, 67*(6), 1. https://doi.org/10.15585/mmwr.ss6706a1

Baker (2019). *Music moves brains to pay attention.* http://med.stanford.edu/news/all-news/2007/07/music-moves-brain-to-pay-attention-stanford-study-finds.html

Baribeau, D. A., & Anagnostou, E. (2014). An update on medication management of behavioral disorders in autism topical collection on child and adolescent disorders. *Current Psychiatry Reports*, *16*(3). https://doi.org/10.1007/s11920-014-0437-0

Barlow, D.H. and Hersen, M. (1984). *Single-Case experimental designs: strategies for studying behavior change* (2nd ed.). Pergamon Press, New York.

Benson, J. D., Donoso Brown, E. V., Blough, A., & Smitsky, D. (2020). The effect of sensorimotor strategies on attention and in-seat behavior in preschoolers with autism spectrum disorder: a pilot study. *Journal of Occupational Therapy, Schools, and Early Intervention*, *13*(3), 236–249. https://doi.org/10.1080/19411243.2020.1732262

Berkeley, S. L., Zittel, L. L., Pitney, L. V., & Nichols, S. E. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly*, *18*(4), 405-416.

Blythe LaGasse, A. (2014). Developmental speech and language training through music (DSLM). *Handbook of Neurologic Music Therapy*, 196.

Boecker, H., Sprenger, T., Spilker, M. E., Henriksen, G., Koppenhoefer, M., Wagner, K. J., Valet, M., Berthele, A., & Tolle, T. R. (2008). The runner's high: Opioidergic mechanisms in the human brain. *Cerebral Cortex*, *18*(11), 2523–2531. https://doi.org/10.1093/cercor/bhn013

Bonnel, A., McAdams, S., Smith, B., Berthiaume, C., Bertone, A., Ciocca, V., Burack, J. A., & Mottron, L. (2010). Enhanced pure-tone pitch discrimination among persons with autism but not Asperger syndrome. *Neuropsychologia*, *48*(9), 2465–2475. https://doi.org/10.1016/j.neuropsychologia.2010.04.020

Brukner-Wertman, Y., Laor, N., & Golan, O. (2016). Social (pragmatic) communication disorder and its relation to the autism spectrum: Dilemmas arising from the DSM-5 classification. *Journal of Autism and Developmental Disorders*, *46*(8), 2821-2829. https://doi.org/10.1007/s10803-016-2814-5

Canella-Malone, H. I., Tullis, C. A., & Kazee, A. R. (2011). Using antecedent exercise to decrease challenging behavior in boys with developmental disabilities and an emotional disorder. *Journal of Positive Behavior Interventions*, *13*(4), 230-239. https://doi.org/10.1177/1098300711406122

Carano, S.L. (2014). Development of a research taxonomy for adapted physical activity. (Doctoral dissertation). Texas Woman's University, Denton, TX. Retrieved from ProQuest Dissertations and Theses. (Accession Order No. 1652477462).

Caria, A., Venuti, P., & De Falco, S. (2011). Functional and dysfunctional brain circuits underlying emotional processing of music in autism spectrum disorders. *Cerebral Cortex*, *21*(12), 2838–2849. https://doi.org/10.1093/cercor/bhr084

Carnahan, C., Musti-Rao, S., & Bailey, J. (2009). Promoting active engagement in small group learning experiences for students with autism and significant learning needs. *Education and Treatment of Children*, *32* (1), 37-61. http://www.jstor.org/stable/42900006

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126-131.

Celiberti, D. A., Bobo, H. E., Kelly, K. S., Harris, S. L., & Handleman, J. S. (1997). The differential and temporal effects of antecedent exercise on the self-stimulatory behavior of a child with autism. Research in Developmental Disabilities, 18(2), 139-150.

Chayer, C., & Freedman, M. (2001). Frontal Lobe Functions. *Current Neurology and Neuroscience Reports*, *1*(6), 547–552. https://doi.org/10.1007/s11910-001-0060-4

Chen, C. C. J. J., Bellama, T. J., Ryuh, Y. J., & Ringenbach, S. D. R. (2019). Examination of participation and performance of dancing movement in individuals with Down syndrome. *International Journal of Developmental Disabilities*, *65*(1), 58–63. https://doi.org/10.1080/20473869.2017.1334307

Collins English Dictionary. (n.d.). *Rhythmic movement definition*. https://www.collinsdictionary.com/us/dictionary/english/rhythmic

Collins, A., & Koechlin, E. (2012). Reasoning, learning, and creativity: Frontal lobe function and human decision-making. *PLoS Biology*, *10*(3), e1001293. https://doi.org/10.1371/journal.pbio.1001293

Corsello, C. M. (2005). Early intervention in autism. *Infants and Young Children*, *18*(2), 74–85. https://doi.org/10.1097/00001163-200504000-00002

Currie, M. (2004). Doing anger differently: A group percussion therapy for angry adolescent boys. *International Journal of Group Psychotherapy*, *54*(3), 275-294. https://doi.org/10.1521/ijgp.54.3.275.40335

Davis, N. O., & Kollins, S. H. (2012). Treatment for co-occurring attention-deficit/hyperactivity disorder and autism spectrum disorder. *Neurotherapeutics*, *9*(3), 518–530. https://doi.org/10.1007/s13311-012-0126-9

De Vries, D., Beck, T., Stacey, B., WInslow, K., & Meines, K. (2015). Music as a therapeutic intervention with autism: a systematic review of the literature. *Therapeutic Recreation Journal*, *49*(3), 220–237.

De Vries, M., & Geurts, H. (2015). Influence of autism traits and executive functioning on quality of life in children with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(9), 2734–2743. https://doi.org/10.1007/s10803-015-2438-1

Dieringer, S. T., & Porretta, D. L. (2013). Using music to decrease off-task behaviors in young children with autism spectrum disorders research application research application. *Palaestra*, *27*(1), 7–10.

Dieringer, S. T., Porretta, D. L., & Sainato, D. (2017). Music and on-task behaviors in preschool children with autism spectrum disorder. *Adapted Physical Activity Quarterly*, *34*(3), 217–234. https://doi.org/10.1123/apaq.2015-0033

Dieringer, S. T., Zoder-Martell, K., Porretta, D. L., Bricker, A., & Kabazie, J. (2017). Increasing physical activity in children with autism through music, prompting, and modeling. *Psychology in the Schools*, *54*(4), 421-432. https://doi.org/10.1002/pits.22003

Dillon, S. R., Adams, D., Goudy, L., Bittner, M., & McNamara, S. (2017). Evaluating exercise as evidence-based practice for individuals with autism spectrum disorder. *Frontiers in Public Health*, *4*, 290. https://doi.org/10.3389/fpubh.2016.00290

Drums Alive. (n.d.). *The Drums Alive® history*. https://www.drums-alive.com/about

Dubnov G., Berry E.M. (2013) Physical Activity and Mood. The Endocrine Connection. In: Constantini N., Hackney A. (eds) Endocrinology of Physical Activity and Sport. Contemporary Endocrinology. Humana Press, Totowa, NJ. https://doi.org/10.1007/978-1-62703-314-5_21

Ecker, C., Suckling, J., Deoni, S. C., Lombardo, M. V., Bullmore, E. T., Baron-Cohen, S., et al. (2012). Brain anatomy and its relationship to behavior in adults with autism spectrum disorder: A multicenter magnetic resonance imaging study. *Archives of General Psychiatry*, *69*(2), 195–209. https://doi.org/10.1001/archgenpsychiatry.2011.1251

Ekins, C., & Owens, D. P. (2018). Drums Alive®: A research-based, multi-disciplinary drumming fitness approach to brain and body health and wellness. *Palaestra*, *32*(4).

Ekins, C., Wright, P. R., Liebich, M., Wright, J., Schulz, H., & Owens, D. (2021). The effects of a drums alive® kids beats intervention on the physical performance and motor skills of children with developmental delays. *Open Journal of Pediatrics*, *11*(4), 832-839. http://doi.org/10.4236/ojped.2021.114078

Ekins, C., Wright, J., Schulz, H., Wright, P. R., Owens, D., & Millder, W. (2019). Effects of a drums alive® kids beats intervention on motor skills and behavior in children with intellectual disabilities. *Palaestra*, *33*(2).

Engel, R. J., & Schutt, R. K. (2016). *The practice of research in social work*. Sage Publications.

Fees, B. S., Kaff, M., Holmberg, T., Teagarden, J., & Delreal, D. (2014). Children's responses to a social story song in three inclusive preschool classrooms: A pilot study. *Music Therapy Perspectives*, *32*(1), 71–77. https://doi.org/10.1093/mtp/miu007

Ferreira, J. P., Ghiarone, T., Cabral Júnior, C. R., Furtado, G. E., Moreira Carvalho, H., Machado-Rodrigues, A. M., & Andrade Toscano, C. V. (2019). Effects of physical exercise on the stereotyped behavior of children with autism spectrum disorders. *Medicina*, *55*(10), 685. https://doi.org/10.3390/medicina55100685

Finn, L., Ramasamy, R., Dukes, C., & Scott, J. (2015). Using WatchMinder to increase the on-task behavior of students with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(5), 1408–1418. https://doi.org/10.1007/s10803-014-2300-x

Flax, J., Gwin, C., Wilson, S., Fradkin, Y., Buyske, S., & Brzustowicz, L. (2019). Social (pragmatic) communication disorder: Another name for the broad autism phenotype? *Autism*, *23*(8), 1982–1992. https://doi.org/10.1177/1362361318822503

Foley, T. E., & Fleshner, M. (2008). Neuroplasticity of dopamine circuits after exercise: Implications for central fatigue. *Neuromolecular Medicine*, *10*(2), 67–80. https://doi.org/10.1007/s12017-008-8032-3

Francis, H. (2011). Effects of 'The Listening Program' on children with profound and multiple learning difficulties. *International Journal of Therapy and Rehabilitation*, *18*(11), 611-621. https://doi.org/10.12968/ijtr.2011.18.11.611

Gebauer, L., Skewes, J., Westphael, G., Heaton, P., & Vuust, P. (2014). Intact brain processing of musical emotions in autism spectrum disorder, but more cognitive load and arousal in happy vs. sad music. *Frontiers in Neuroscience*, *8*, 192. https://doi.org/10.3389/fnins.2014.00192

Geretsegger, M., Elefant, C., Mössler, K. A., & Gold, C. (2014). Music therapy for people with autism spectrum disorder. *Cochrane Database of Systematic Reviews*, *2016*(3). https://doi.org/10.1002/14651858.CD004381.pub3

Gersten, R., Fuchs, L. S., Compton, D., Coyne, M., Greenwood, C., & Innocenti, M. S. (2005). Quality indicators for group experimental and quasi-experimental research in special education. *Exceptional Children*, *71*(2), 149-164. https://doi.org/10.1177/001440290507100202

Gibbs, A. R., Tullis, C. A., Thomas, R., & Elkins, B. (2018). The effects of noncontingent music and response interruption and redirection on vocal stereotypy. *Journal of Applied Behavior Analysis*, *51*(4), 899-914. https://doi.org/10.1002/jaba.485

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., & Baird, G. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine and Child Neurology*, *51*(4), 311–316. https://doi.org/10.1111/j.1469-8749.2008.03242.x

Griffin, W., & AFIRM Team. (2015). *Exercise.* Chapel Hill, NC: National Professional Development Center on Autism Spectrum Disorder, FPG Child Development Center, University of North Carolina. http://afirm.fpg.unc.edu/exercise

Gunsberg, A. (1988). Improvised musical play: A strategy for fostering social play between developmentally delayed and nondelayed preschool children. *Journal of Music Therapy*, *25*(4), 178–191. https://doi.org/10.1093/jmt/25.4.178

Guzic, B. L., Tonkin, K., Roberts, J. B., & Demuth, B. R. (2011). Using percussion to improve attention-to-tasks in children with autism. *Exceptional Parent*, *41*(3), 18-20.

Hall, N. E., & Segarra, V. R. (2007). Predicting academic performance in children with language impairment: The role of parent report. *Journal of Communication Disorders*, *40*(1), 82-95. https://doi.org/10.1016/j.jcomdis.2006.06.001

Hardy, M. W., & LaGasse, A. B. (2013). Rhythm, movement, and autism: Using rhythmic rehabilitation research as a model for autism. *Frontiers in Integrative Neuroscience*, *7*, 19. https://doi.org/10.3389/fnint.2013.00019

Hauck, J. L., Ketcheson, L. R., & Ulrich, D. A. (2016). Methodology to promote physical activity monitoring adherence in youth with autism spectrum disorder. *Frontiers in Public Health*, *4*, 206. https://doi.org/10.3389/FPUBH.2016.00206

Heijnen, S., Hommel, B., Kibele, A., & Colzato, L. S. (2016). Neuromodulation of aerobic exercise-A review. *Frontiers in Psychology*, *6*, 1890. https://doi.org/10.3389/fpsyg.2015.01890

Ho, P., Tsao, J. C. I., Bloch, L., & Zeltzer, L. K. (2011). The impact of group drumming on social-emotional behavior in low-income children. *Evidence-Based Complementary and Alternative Medicine*, *2011*, 111. https://doi.org/10.1093/ecam/neq072

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*(2), 165-179. https://doi.org/10.1177/001440290507100203

Howells, K., Sivaratnam, C., May, T., Lindor, E., McGillivray, J., & Rinehart, N. (2019). Efficacy of group-based organized physical activity participation for social outcomes in children with autism spectrum disorder: A systematic review and meta-analysis. *Journal of Autism and Developmental Disorders*, *49*(8), 3290–3308. https://doi.org/10.1007/s10803-019-04050-9

Howie, E. K., Barnes, T. L., McDermott, S., Mann, J. R., Clarkson, J., & Meriwether, R. A. (2012). Availability of physical activity resources in the environment for adults with intellectual disabilities. *Disability and Health Journal*, *5*(1), 41–48. https://doi.org/10.1016/j.dhjo.2011.09.004

Hsia, Y., Wong, A. Y. S., Murphy, D. G. M., Simonoff, E., Buitelaar, J. K., & Wong, I. C. K. (2014). Psychopharmacological prescriptions for people with autism spectrum disorder (ASD): A multinational study. *Psychopharmacology*, *231*(6), 999–1009. https://doi.org/10.1007/s00213-013-3263-x https://doi.org/10.1007/978-1-4614-4989-8_41

In J. (2017). Introduction of a pilot study. *Korean Journal of Anesthesiology*, *70*(6), 601–605. https://doi.org/10.4097/kjae.2017.70.6.601

Iverson, J. M. (2010). Developing language in a developing body: The relationship between motor development and language development. *Journal of Child Language*, *37*(2), 229-261. https://doi.org/10.1017/S0305000909990432

Jachyra, P., Renwick, R., Gladstone, B., Anagnostou, E., & Gibson, B. E. (2021). Physical activity participation among adolescents with autism spectrum disorder. *Autism*, *25*(3), 613–626. https://doi.org/10.1177/1362361320949344

Ji, Z., Feng, T., Mei, L., Li, A., & Zhang, C. (2019). Influence of acute combined physical and cognitive exercise on cognitive function: An NIRS study. *Peer Journal*, *7*: e7418. https://doi.org/10.7717/peerj.7418

Kalas, A. (2012). Joint attention responses of children with autism spectrum disorder to simple versus complex music. *Journal of Music Therapy*, *49*(4), 430-452. https://doi.org/10.1093/jmt/49.4.430

Kaplan, R. S., & Steele, A. L. (2005). An analysis of music therapy program goals and outcomes for clients with diagnoses on the autism spectrum. *Journal of Music Therapy*, *42*(1), 2-19. https://doi.org/10.1093/jmt/42.1.2

Kasuya-Ueba, Y., Zhao, S., & Toichi, M. (2020). The effect of music intervention on attention in children: Experimental evidence. *Frontiers in Neuroscience*, *14*, 757. https://doi.org/10.3389/fnins.2020.00757

Kern, P., Wolery, M., & Aldridge, D. (2007). Use of songs to promote independence in morning greeting routines for young children with autism. *Journal of Autism and Developmental Disorders*, *37*(7), 1264-1271. https://doi.org/10.1007/s10803-006-0272-1

Kennedy, C. H. (2005). *Single-case designs for educational research* (Vol. 1). Boston: Pearson/A & B.

Kim, M., & Tomaino, C. M. (2008). Protocol evaluation for effective music therapy for persons with nonfluent aphasia. *Topics in Stroke Rehabilitation*, *15*(6), 555–569. https://doi.org/10.1310/tsr1506-555

Knappová, V., & Kavalířová, G. (2013). Drums Alive®–drumming on exercise balls as the mean of development of coordination. *Studia Sportiva*, *7*(3), 137–145. https://doi.org/10.5817/StS2013-3-11

Koshimori, Y., & Thaut, M. H. (2019). New perspectives on music in rehabilitation of executive and attention functions. *Frontiers in Neuroscience*, *13*, 1–6. https://doi.org/10.3389/fnins.2019.01245

LaGasse, A. B. (2014). Effects of a music therapy group intervention on enhancing social skills in children with autism. *Journal of Music Therapy*, *51*(3), 250-275. https://doi.org/10.1093/jmt/thu012

LaGasse, A. B., Manning, R. C., Crasta, J. E., Gavin, W. J., & Davies, P. L. (2019). Assessing the impact of music therapy on sensory gating and attention in children with autism: a pilot and feasibility study. *Journal of Music Therapy*, *56*(3), 287-314. https://doi.org/10.1093/jmt/thz008

LaGasse, B. (2017). Social outcomes in children with autism spectrum disorder: a review of music therapy outcomes. *Patient Related Outcome Measures*, *8*, 23–32. https://doi.org/10.2147/prom.s106267

Lai, C. L. E., Lau, Z., Lui, S. S., Lok, E., Tam, V., Chan, Q., Cheng, K. M., Lam, S. M., & Cheung, E. F. (2017). Meta-analysis of neuropsychological measures of executive functioning in children and adolescents with high-functioning autism spectrum disorder. *Autism Research*, *10*(5), 911-939. https://doi.org/10.1002/aur.1723

Lai, G., Pantazatos, S. P., Schneider, H., & Hirsch, J. (2012). Neural systems for speech and song in autism. *Brain*, *135*(3), 961–975. https://doi.org/10.1093/brain/awr335

Lamy, M., & Erickson, C. A. (2018). Pharmacological management of behavioral disturbances in children and adolescents with autism spectrum disorders. *Current Problems in Pediatric and Adolescent Health Care*, *48*(10), 250–264. https://doi.org/10.1016/j.cppeds.2018.08.015

Lamy, M., Pedapati, E. V., Dominick, K. L., Wink, L. K., & Erickson, C. A. (2020). Recent advances in the pharmacological management of behavioral disturbances associated with autism spectrum disorder in children and adolescents. *Pediatric Drugs*, *22*(5), 473–483. https://doi.org/10.1007/s40272-020-00408-0

Lang, R., Koegel, L. K., Ashbaugh, K., Regester, A., Ence, W., & Smith, W. (2010). Physical exercise and individuals with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders*, *4*(4), 565–576. https://doi.org/10.1016/j.rasd.2010.01.006

Lee, J., Vargo, K. K., & Porretta, D. L. (2018). An evaluation of the effects of antecedent exercise type on stereotypic behaviors. *Journal of Developmental and Physical Disabilities*, *30*(3), 409–426. https://doi.org/10.1007/s10882-018-9593-1

Lei, Y., & Wang, J. (2018). The effect of proprioceptive acuity variability on motor adaptation in older adults. *Experimental Brain Research*, *236*(2), 599-608. https://doi.org/10.1007/s00221-017-5150-x

Leitner, Y. (2014). The co-occurrence of autism and attention deficit hyperactivity disorder in children – what do we know? *Frontiers in Human Neuroscience*, *8*, 268. https://doi.org/10.3389/fnhum.2014.00268

Lim, H. A. (2009). Use of music to improve speech production in children with autism spectrum disorders: Theoretical orientation. *Music Therapy Perspectives*, *27*(2), 103-114. https://doi.org/10.1093/mtp/27.2.103

Lim, H. A. (2010). Effect of "developmental speech and language training through music" on speech production in children with autism spectrum disorders. *Journal of Music Therapy*, *47*(1), 2-26. https://doi.org/10.1093/jmt/47.1.2

Lowry, R. G., Hale, B. J., Draper, S. B., & Smith, M. S. (2019). Rock drumming enhances motor and psychosocial skills of children with emotional and behavioral difficulties. *International Journal of Developmental Disabilities*, *65*(3), 152–161. https://doi.org/10.1080/20473869.2018.1429041

MacDonald, M., Lord, C., & Ulrich, D. A. (2013). The relationship of motor skills and social communicative skills in school-aged children with autism spectrum disorder. *Adapted Physical Activity Quarterly*, *30*(3), 271–282. https://doi.org/10.1123/apaq.30.3.271

Martin, J., Hamshere, M. L., Stergiakouli, E., O'Donovan, M. C., & Thapar, A. (2014). Genetic risk for attention-deficit/hyperactivity disorder contributes to neurodevelopmental traits in the general population. *Biological Psychiatry*, *76*(8), 664–671. https://doi.org/10.1016/j.biopsych.2014.02.013

Martin, K. E., & Wood, L. J. (2017). Drumming to a new beat: A group therapeutic drumming and talking intervention to improve mental health and behaviour of disadvantaged adolescent boys. *Children Australia*, *42*(4), 268-276. https://doi.org/10.1017/cha.2017.40

Maschi, T., & Bradley, C. (2010). Recreational drumming: A creative arts intervention strategy for social work teaching and practice. *Journal of Baccalaureate Social Work*, *15*(1), 53–66. https://doi.org/10.18084/basw.15.1.57743r4647823mw0

Maschi, T., MacMillan, T., & Viola, D. (2013). Group drumming and well-being: A promising self-care strategy for social workers. *Arts and Health*, *5*(2), 142–151. https://doi.org/10.1080/17533015.2012.748081

Mattard-Labrecque, C., Ben Amor, L., & Couture, M. M. (2013). Children with autism and attention difficulties: A pilot study of the association between sensory, motor, and adaptive behaviors. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *22*(2), 139–146.

McDuffie, A. (2021). Verbal Communication. *Encyclopedia of Autism Spectrum Disorders*, 5029-5029. https://doi.org/10.1007/978-3-319-91280-6

Meltzer, J., & Hamann, E. T. (2005). *Meeting the Literacy Development Needs of Adolescent English Language Learners Through Content-Area Learning-PART TWO: Focus on Classroom Teaching and Learning Strategies*.

Menear, K. S., & Neumeier, W. H. (2015). Promoting physical activity for students with autism spectrum disorder: barriers, benefits, and strategies for success. *Journal of Physical Education, Recreation & Dance*, *86*(3), 43–48. https://doi.org/10.1080/07303084.2014.998395

Merriam-Webster. (n.d.). *Music definition*. https://www.merriam-webster.com/dictionary/music

Miramontez, S. K. H., & Schwartz, I. S. (2016). The effects of physical activity on the on-task behavior of young children with autism spectrum disorders. *International Electronic Journal of Elementary Education*, *9*(2), 405–418.

Molnar-Szakacs, I., Wang, M. J., Laugeson, E. A., Overy, K., Wu, W.L., & Piggot, J. (2009). Autism, emotion recognition and the mirror neuron system: the case of music. *McGill Journal of Medicine: MJM: An International Forum for the Advancement of Medical Sciences by Students*, *12*(2), 87.

Montgomery, J., Storey, K., Post, M., & Lemley, J. (2011). The use of auditory prompting systems for increasing independent performance of students with autism in employment training. *International Journal of Rehabilitation Research*, *34*(4), 330-335. https://doi: 10.1097/MRR.0b013e32834a8fa8

Morrison, H., Roscoe, E. M., & Atwell, A. (2011). An evaluation of antecedent exercise on behavior maintained by automatic reinforcement using a three-component multiple schedule. *Journal of Applied Behavior Analysis*, *44*(3), 523-541. https://doi.org/10.1901/jaba.2011.44-523

Murray, M. L., Hsia, Y., Glaser, K., Simonoff, E., Murphy, D. G. M., Asherson, P. J., Eklund, H., & Wong, I. C. K. (2014). Pharmacological treatments prescribed to people with autism spectrum disorder (ASD) in primary health care. *Psychopharmacology*, *231*(6), 1011–1021. https://doi.org/10.1007/s00213-013-3140-7

Nakutin, S. N., & Gutierrez, G. (2019). Effect of physical activity on academic engagement and executive functioning in children with ASD. *School Psychology Review*, *48*(2), 177–184. https://doi.org/10.17105/SPR-2017-0124.V48-2

National Professional Development Center on Autism Spectrum Disorder. (2014). Evidence-Based Practices. https://autismpdc.fpg.unc.edu/evidence-based-practices

Neely, L., Rispoli, M., Gerow, S., & Ninci, J. (2015). Effects of antecedent exercise on academic engagement and stereotypy during instruction. *Behavior Modification*, *39*(1). https://doi.org/10.1177/0145445514552891

Neitzel, J. (2010). Positive behavior supports for children and youth with autism spectrum disorders. *Preventing School Failure: Alternative Education for Children and Youth*, *54*(4), 247–255. https://doi.org/10.1080/10459881003745229

Nicholson, H., Kehle, T. J., Bray, M. A., & Heest, J. V. (2011). The effects of antecedent physical activity on the academic engagement of children with autism spectrum disorder. *Psychology in the Schools*, *48*(2), 198-213.

O'Connor, J., & Dieringer, S. T. (2014). Effect of humpback whale sounds, didgeridoo, and music on select behaviors of a youth with autism spectrum disorder. *Palaestra*, *28*(1), 10–13.

Odom, S. L., Brantlinger, E., Gersten, R., Horner, R. H., Thompson, B., & Harris, K. R. (2005). Research in special education: Scientific methods and evidence-based practices. *Exceptional Children*, *71*(2), 137-148. https://doi.org/10.1177/001440290507100201

Oriel, K. N., George, C. L., Peckus, R., & Semon, A. (2011). The effects of aerobic exercise on academic engagement in young children with autism spectrum disorder. *Pediatric Physical Therapy*, *23*(2), 187–193. https://doi.org/10.1097/PEP.0b013e318218f149

Ouimet, T., Foster, N. E. V., & Hyde, K. L. (2012). Auditory global-local processing: Effects of attention and musical experience. *The Journal of the Acoustical Society of America*, *132*(4), 2536–2544. https://doi.org/10.1121/1.4747009

Palmen, A., Didden, R., & Lang, R. (2012). A systematic review of behavioral intervention research on adaptive skill building in high-functioning young adults with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *6*(2), 602–617. https://doi.org/10.1016/j.rasd.2011.10.001

Pan, C. Y., & Frey, G. C. (2006). Physical activity patterns in youth with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *36*(5), 597–606. https://doi.org/10.1007/s10803-006-0101-6

Pasiali, V., LaGasse, A. B., & Penn, S. L. (2014). The effect of musical attention control training (MACT) on attention skills of adolescents with neurodevelopmental delays: A pilot study. *Journal of Music Therapy*, *51*(4), 333-354.

Paul, R. (2008). Interventions to improve communication in autism. *Child and Adolescent Psychiatric Clinics of North America*, *17*(4), 835–856. https://doi.org/10.1016/j.chc.2008.06.011

Pokorski, E. A., Barton, E. E., Ledford, J. R., Taylor, A. L., Johnson, E., & Winters, H. K. (2019). Comparison of antecedent activities for increasing engagement in a preschool child with ASD during a small group activity. *Education and Training in Autism and Developmental Disabilities*, *54*(1), 94–103.

Preis, J., Amon, R., Silbert Robinette, D., & Rozegar, A. (2016). Does music matter? The effects of background music on verbal expression and engagement in children with autism spectrum disorders. *Music Therapy Perspectives*, *34*(1), 106–115. https://doi.org/10.1093/mtp/miu044

Ragone, G., Good, J., & Howland, K. (2021). How technology applied to music-therapy and sound-based activities addresses motor and social skills in autistic children. *Multimodal Technologies and Interaction*, *5*(3). https://doi.org/10.3390/mti5030011

Reiersen, A. M., & Todd, R. D. (2008). Co-occurrence of ADHD and autism spectrum disorders: Phenomenology and treatment. *Expert Review of Neurotherapeutics*, *8*(4), 657–669. https://doi.org/10.1586/14737175.8.4.657

Reiersen, A. M., Constantino, J. N., Volk, H. E., & Todd, R. D. (2007). Autistic traits in a population-based ADHD twin sample. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *48*(5), 464–472. https://doi.org/10.1111/j.1469-7610.2006.01720.x

Reschke-Hernández, A. E. (2011). History of Music Therapy Treatment Interventions for Children with Autism. *Journal of Music Therapy*, *48*(2), 169-207.

Rhythmic Movement Training International. (2010). *What is Rhythmic Movement Training International (RMTi)*? https://www.rhythmicmovement.org/rmt-explained

Richards, S. B. (2018). *Single-subject research: Applications in educational settings*. Cengage Learning.

Richler, J., Huerta, M., Bishop, S. L., & Lord, C. (2010). Developmental trajectories of restricted and repetitive behaviors and interests in children with autism spectrum disorders. *Development and Psychopathology*, *22*(1), 55. https://doi: 10.1017/S0954579409990265

Rossi, A. F., Pessoa, L., Desimone, R., & Ungerleider, L. G. (2009). The prefrontal cortex and the executive control of attention. *Experimental Brain Research*, *192*(3), 489–497. https://doi.org/10.1007/s00221-008-1642-z

Rueckert, L., & Grafman, J. (1998). Sustained attention deficits in patients with lesions of posterior cortex. *Neuropsychologia*, *36*(7), 653–660. https://doi.org/10.1016/S0028-3932(97)00150-4

Sam, A. (2016). Antecedent-Based Intervention (ABI). EBP Brief Packet. *National Professional Development Center on Autism Spectrum Disorders*.

Santosh, P. J., & Mijovic, A. (2004). Social impairment in hyperkinetic disorder: Relationship to psychopathology and environmental stressors. *European Child and Adolescent Psychiatry*, *13*(3), 141–150. https://doi.org/10.1007/s00787-004-0372-4

Santosh, P. J., Baird, G., Pityaratstian, N., Tavare, E., & Gringras, P. (2006). Impact of comorbid autism spectrum disorders on stimulant response in children with attention deficit hyperactivity disorder: a retrospective and prospective effectiveness study. *Child: Care, Health and Development*, *32*(5), 575-583. https://doi.org/10.1111/j.1365-2214.2006.00631.x

Scalzo, R., Henry, K., Davis, T. N., Amos, K., Zoch, T., Turchan, S., & Wagner, T. (2015). Evaluation of interventions to reduce multiply controlled vocal stereotypy. *Behavior Modification*, *39*(4), 496-509. https://doi.org/10.1177/0145445515573986

Shi, Z.-M., Lin, G.-H., & Xie, Q. (2016). Effects of music therapy on mood, language, behavior, and social skills in children with autism: A meta-analysis. *Chinese Nursing Research*, *3*(3), 137–141. https://doi.org/10.1016/j.cnre.2016.06.018

Shimizu, N., Umemura, T., Matsunaga, M., & Hirai, T. (2018). Effects of movement music therapy with a percussion instrument on physical and frontal lobe function in older adults with mild cognitive impairment: a randomized controlled trial. *Aging and Mental Health*, *22*(12), 1614–1626. https://doi.org/10.1080/13607863.2017.1379048

Simpson, K., Keen, D., & Lamb, J. (2013). The use of music to engage children with autism in a receptive labelling task. *Research in Autism Spectrum Disorders*, *7*(12), 1489-1496. https://doi.org/10.1016/j.rasd.2013.08.013

Sowa, M., & Meulenbroek, R. (2012). Effects of physical exercise on autism spectrum disorders: A meta-analysis. *Research in Autism Spectrum Disorders*, *6*(1), 46–57. https://doi.org/10.1016/j.rasd.2011.09.001

Srinivasan, S. M., Kaur, M., Park, I. K., Gifford, T. D., Marsh, K. L., & Bhat, A. N. (2015). The effects of rhythm and robotic interventions on the imitation/praxis, interpersonal synchrony, and motor performance of children with autism spectrum disorder (ASD): A pilot randomized controlled trial. *Autism Research and Treatment*, *2015*, 1–18. https://doi.org/10.1155/2015/736516

Stamou, A., Roussy, A. B., Ockelford, A., & Terzi, L. (2019). The effectiveness of a music and dance program on the task engagement and inclusion of young pupils on the autism spectrum. *Music & Science*, *2*, 2059204319881852. https://doi.org/10.1177/2059204319881852

Staples, K. L., & Reid, G. (2010). Fundamental movement skills and autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *40*(2), 209–217. https://doi.org/10.1007/s10803-009-0854-9

Steinbrenner, J. R., Hume, K., Odom, S. L., Morin, K. L., Nowell, S. W., Tomaszewski, B., Szendrey, S., Mclntyre, N.S., Yücesoy-Özkan, S., & Savage, M. N. (2020). Evidence-Based Practices for Children, Youth, and Young Adults with Autism. *FPG Child Development Institute*.

Sterling-Turner, H. E., Robinson, S. L., & Wilczynski, S. M. (2001). Functional assessment of distracting and disruptive behaviors in the school setting. *School Psychology Review*, *30*(2), 211–226. https://doi.org/10.1080/02796015.2001.12086110

Su, Y., Li, M., & Tong, X. (2020). A case study of the use of Taiko drumming to improve attention and social interaction skills for remote children with learning disabilities. *Journal of Social Science and Humanities*, *3*(1): 31-43.

Sung, H. C., Lee, W. L., Li, T. L., & Watson, R. (2012). A group music intervention using percussion instruments with familiar music to reduce anxiety and agitation of institutionalized older adults with dementia. *International Journal of Geriatric Psychiatry*, *27*(6), 621-627. https://doi.org/10.1002/gps.2761

Texas Autism Resource Guide for Effective Teaching. (n.d.). *Antecedent-Based Intervention*. https://www.txautism.net/interventions/antecedent-based-interventions

Thabane, L., Ma, J., Chu, R., Cheng, J., Ismaila, A., Rios, L. P., Robson, R., Thabane, M., Giangregorio, L., & Goldsmith, C. H. (2010). A tutorial on pilot studies: the what, why and how. *BMC Medical Research Methodology*, *10*(1), 1-10. https://doi.org/10.1186/1471-2288-10-1

Thaut, M. H., & Abiru, M. (2010). Rhythmic auditory stimulation in rehabilitation of movement disorders: a review of current research. *Music Perception*, 27(4), 263-269. https://doi.org/10.1525/mp.2010.27.4.263

Thaut, M. H., McIntosh, G. C., & Hoemberg, V. (2015). Neurobiological foundations of neurologic music therapy: rhythmic entrainment and the motor system. *Frontiers in Psychology*, *5*, 1185. https://doi.org/10.3389/fpsyg.2014.01185

Theofilou, P., & Reyes Saborit, A. (2013). Adherence and physical activity. *Health Psychology Research*, *1*(1), 6. https://doi.org/10.4081/hpr.2013.e6

Titus, S., & Porretta, D. L. (2012). Using music to decrease off-task behavior in children with autism. *Research Quarterly for Exercise and Sport*, *83*(1).

Tomporowski, P. D., & Pesce, C. (2019). Exercise, sports, and performance arts benefit cognition via a common process. Psychological Bulletin, 145(9), 929. https://doi.org/10.1037/bul0000200

Tryfon, A., Foster, N. E., Ouimet, T., Doyle-Thomas, K., Anagnostou, E., Sharda, M., & Hyde, K. L. (2017). Auditory-motor rhythm synchronization in children with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *35*, 51–61. https://doi.org/10.1016/j.rasd.2016.12.004

Tse, A. C. (2020). Brief report: Impact of a physical exercise intervention on emotion regulation and behavioral functioning in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *50*(11), 4191-4198. https://doi.org/10.1007/s10803-020-04418-2

Tsujii, T., Komatsu, K., & Sakatani, K. (2013). Acute effects of physical exercise on prefrontal cortex activity in older adults: a functional near-infrared spectroscopy study. *Advances in Experimental Medicine and Biology*, 765, 293–298.

Unwin, K. L., Powell, G., & Jones, C. R. G. (2021). The use of multi-sensory environments with autistic children: Exploring the effect of having control of sensory changes. *Autism.* 13623613211050176. https://doi.org/10.1177/13623613211050176

Vanderbilt University's Peabody College, the IRIS Center. (n.d.). Evidence-Based Practice. https://iris.peabody.vanderbilt.edu/

Vazou, S., Klesel, B., Lakes, K. D., & Smiley, A. (2020). Rhythmic physical activity intervention: exploring feasibility and effectiveness in improving motor and executive function skills in children. *Frontiers in Psychology*, *11*, 2392. https://doi.org/10.3389/fpsyg.2020.556249

Wan, C. Y., & Schlaug, G. (2010). Neural pathways for language in autism: the potential for music-based treatments. *Future Neurology*, *5*(6), 797-805. https://doi.org/10.2217/fnl.10.55

Wang, J. G., Cai, K. L., Liu, Z. M., Herold, F., Zou, L., Zhu, L. N., Xiong, X., & Chen, A. G. (2020). Effects of mini-basketball training program on executive functions and core symptoms among preschool children with autism spectrum disorders. *Brain Sciences*, *10*(5), 1–14. https://doi.org/10.3390/brainsci10050263

Warreyn, P., & Roeyers, H. (2014). See what I see, do as I do: Promoting joint attention and imitation in preschoolers with autism spectrum disorder. *Autism*, *18*(6), 658–671. https://doi.org/10.1177/1362361313493834

Willemin, T., Litchke, L. G., Liu, T., & Ekins, C. (2018). Social emotional effects of drumtastic®: A dyadic within-group drumming pilot program for children with autism spectrum disorder. *International Journal of Special Education*, *33*(1), 94–103.

Williams, K. E. (2018). Moving to the beat: using music, rhythm, and movement to enhance self-regulation in early childhood classrooms. *International Journal of Early Childhood*, *50*(1), 85–100. https://doi.org/10.1007/s13158-018-0215-y

Wong, C., Odom, S. L., Hume, K. A., Cox, A. W., Fettig, A., Kucharczyk, S., Brock, M. E., Plavnick, J. B., Fleury, V. P., & Schultz, T. R. (2015). Evidence-based practices for children, youth, and young adults with autism spectrum disorder: A comprehensive review. *Journal of Autism and Developmental Disorders*, *45*(7), 1951–1966. https://doi.org/10.1007/s10803-014-2351-z

Wozniak, R. H., Leezenbaum, N. B., Northrup, J. B., West, K. L., & Iverson, J. M. (2017). The development of autism spectrum disorders: variability and causal complexity. *Wiley Interdisciplinary Reviews: Cognitive Science*, *8*(1-2), e1426. https://doi.org/10.1002/wcs.1426

World Health Organization. (2021). *Autism spectrum disorder*. https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders

Yang, Q., Yang, J., Keener, E., Oh, J., Gomes, A., & Dillon, S. (2021). Drums-Alive intervention effect on the motor and functional skills in youth with intellectual disabilities and autism spectrum disorder: A pilot study. *Advances in Physical Education, 11*(1), 35-46. http://doi.prg/10.4236/ape.2021.111003

Yoo, G. E., & Kim, S. J. (2018). Dyadic drum playing and social skills: Implications for rhythm-mediated intervention for children with autism spectrum disorder. *Journal of Music Therapy*, *55*(3), 340-375. https://doi.org/10.1093/jmt/thy013

Zablotsky, B., Black, L. I., Maenner, M. J., Schieve, L. A., & Blumberg, S. J. (2015). Estimated prevalence of autism and other developmental disabilities following questionnaire changes in the 2014 National Health Interview Survey. *National Health Statistics Reports*, *87*, 1–20. https://stacks.cdc.gov/view/cdc/38790

Zatorre, R. J., Chen, J. L., & Penhune, V. B. (2007). When the brain plays music: Auditory-motor interactions in music perception and production. *Nature Reviews Neuroscience*, *8*(7), 547–558. https://doi.org/10.1038/nrn2152

APPENDIX A

ADAPTED PHYSICAL ACTIVITY TAXONOMY QUALITY EVALUATION CRITERIA AND LEVEL OF RECOMMENDATION

Part I: Quality of the Study Format	**APAT: Experimental/Quasi Experimental Design Based on the Strength of Recommendation**				
Strength of Quality	**Domain I: Introductory Section**	**Domain II: Method Section**	**Domain III: Results Section**	**Domain IV: Discussion Section**	**Domain V: Other**
Level 1 (Strong)	Indicators: • Hypothesis(es)/ research question(s) is/are clearly stated • If appropriate there is a clear application to theory or conceptual model • Significance and need for the study is clearly demonstrated • Purpose statement for the study is clearly aligned with hypothesis(es)/ research question(s) • Solutions to the challenges are provided • Literature supports purpose and justification of the study Indicator evaluation	Indicators: • Research design appropriately aligns with the hypothesis(es)/research question(s) • Research instrument(s) have been currently validated and show reliability within the target population • Appropriate measures are used to control for participant and researcher bias • Data collection is conducted throughout the course of the treatment; if appropriate substantial baseline measurements are obtained • Participants selected, clearly reflect the intended study • Population is adequately represented and includes description of inclusion/exclusion criteria • Sampling technique(s) is/are described in depth • Researcher(s) provide(s) sufficient information for replication of the study and includes description of the setting • Treatment levels, intervention, and/or conditions are thoroughly explained and/or documented • Participant confidentiality is clearly addressed • Participants characteristics are comparable across conditions • Fidelity is clearly described and assessed Indicator evaluation	Indicators: • Power is $\geq$ 0.8 • Clear description and analyses of raw data • Results address the hypothesis(es)/ research question(s) • Effect size is provided • Reliability and validity interpretations are very detailed Indicator evaluation	Indicators: • Discussion of results clearly address the hypothesis(es)/research question(s) • Findings are compared to appropriate prior research • Limitation of the study are clearly identified • Recommendation for future studies are clear and detailed • Representativeness addresses target population and other possible issues Indicator evaluation	Indicators: • Contains a complete listing of references pertinent to the study concept • Appendices are provided when appropriate Indicator evaluation

Strength of Quality	Domain I: Introductory Section	Domain II: Method Section	Domain III: Results Section	Domain IV: Discussion Section	Domain V: Other
Level 2 (Moderate)	Indicators: • Hypothesis(es)/ research question(s) is/are present but not clear • If appropriate there is limited application to theory or conceptual model • Significance and need for the study is not clearly demonstrated • Purpose statement does not clearly align with hypothesis(es)/ research question(s) • Some solutions to challenges are provided • Literature lacks direct connection to the purpose and justification of the study Indicator evaluation	Indicators: • Research design somewhat aligns with the hypothesis(es)/research question(s) • Research instrument(s) do not demonstrate current validity and reliability in target population • Limited measures are used to control for participant and researcher bias • Data collection is conducted throughout the course of the treatment; if appropriate a weak baseline is determined • Participants selected vaguely reflect the intended purpose of the study • Population is underrepresents and may not provide a description of inclusion/exclusion criteria • Sampling technique(s) is/are described but is not replicable • Researcher(s) provide adequate information for replication of study and setting is adequately described • Treatment levels, intervention, and/or conditions are adequately explained and documented • Participant confidentiality is present but not clear • Participants characteristics have limited comparison across conditions • Fidelity is not fully described and assessed Indicator evaluation	Indicators: • Power is between 0.7 to 0.79 • Analyses of raw data are presented but description lacks clarity • Not all results align with hypothesis(es)/ research questions • Effect size is inconsistently provided • Reliability and validity interpretation lack detail Indicator evaluation	Indicators: • Discussion of results does not clearly address the hypothesis(es)/research question(s) • Findings are present but not all are connected to appropriate prior research • Limitations are mentioned but not clearly identified • Recommendation are mentioned but not addressed in detail • Representativeness addresses target population and other possible issues but is limited Indicator evaluation	Indicators: • Partial inclusion of references pertinent to the study concept • Appendices are incomplete when appropriate Indicator evaluation

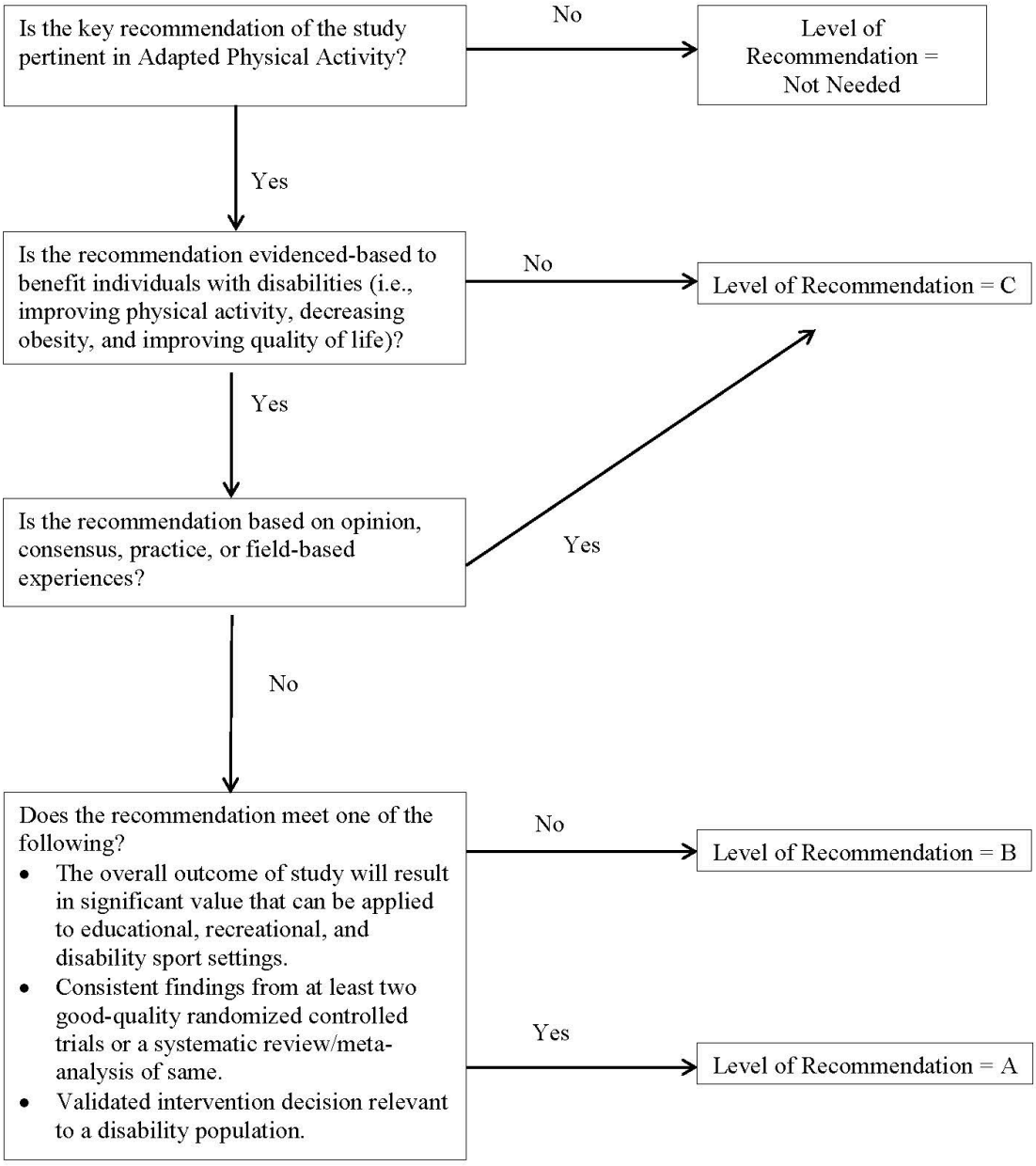
Strength of Quality	Domain I: Introductory Section	Domain II: Method Section	Domain III: Results Section	Domain IV: Discussion Section	Domain V: Other
Level 3 (Weak)	Indicators: • Hypothesis(es)/ research question(s) are not present • If appropriate there is no application to theory and/or conceptual model • Significance and need for the study is not identified or is opinion based • Purpose statement does not align with hypothesis(es)/ research question(s) • Solutions to challenges are not provided • Literature has no clear connection to the purpose and justification of the study	Indicators: • Research design does not align with the hypothesis(es)/research question(s) • Research instrument(s) does not clearly demonstrate current validity and reliability • No apparent measures are taken to control for participant bias • Data collection was not conducted throughout the course of the treatment; if appropriate, no baseline were determined • Participants selected do not reflect the intended purpose of the study • Participant selection does not align with study and does not include a description of inclusion/exclusion criteria • Sampling technique(s) is/are not provided • Researcher(s) provide insufficient information for replication of study and setting is not addressed • Treatment level, intervention, and/or conditions are inadequately explained and/or documented • Participant confidentiality is not addressed • Participant characteristics are not comparable across conditions • Fidelity is not described and assessed	Indicators: • Power is ≤ 0.69 • Raw data were missing and/or not clear • Results do not align with hypothesis(es)/ research questions • Effect size is not provided • Reliability and validity interpretation are unclear and without detail	Indicators: • Discussion does not clearly address the hypothesis(es)/research question(s) • Findings are not connected to appropriate prior research • Limitations are not identified • Limited or no recommendations to future research is presented • Representativeness does not addresses target population and other possible issues	Indicators: • Does not include references pertinent to the study concept • Appendices are not provided when appropriate Indicator evaluation

Part I: Quality of the Study	APAT: Single Subject Design Based on the Strength of Recommendation Format				
Strength of Quality	**Domain I: Introductory Section**	**Domain II: Method Section**	**Domain III: Results Section**	**Domain IV: Discussion Section**	**Domain V: Other**
Level 1 (Strong)	Indicators: • Hypothesis(es)/ research question(s) are clearly stated • There is a clear application to theory or conceptual model • Significance and need for the study is clearly demonstrated • Purpose statement for the study clearly aligns with hypothesis(es)/ research question(s) • Solutions to the challenges are provided • Literature supports the purpose and justification of the study Indicator evaluation	Indicators: • Research design appropriately aligns with the hypothesis(es)/research question(s) • Data collection was conducted throughout the course of the treatment to substantiate trustworthiness; if appropriate, substantial baseline measurements are obtained • Participants selected, clearly reflect the intended study • Population is adequately represented • Population includes full description of inclusion and exclusion criteria • Researcher(s) provides sufficient information for replication of the study and includes description of setting • Sample technique(s) is/are described in depth • Dependent variable (DV) and Independent variable (IV) levels, intervention, and conditions are thoroughly explained, documented, and replicable • DV is quantifiable • IV is manipulated under the control of the experimenter • Participant criteria are fully described to the extent that is replicable • Participant confidentiality is clearly addressed • Baseline data are systematic and provide evidence for repeated measurement over time • Threats to internal validity are thoroughly addressed Indicator evaluation	Indicators: • Percent agreement between observers is $\geq$ 80%, or coefficient r is $\geq$ 0.7 • Analyses of raw data is clearly described • A pattern of experimental control is clearly discussed • At least 3 different experimental effects over 3 different periods of time are clearly presented Indicator evaluation	Indicators: • Discussion of results clearly address the hypothesis(es)/research question(s) • Findings are compared to appropriate prior research • Limitations of the study are clearly identified • Recommendation for future studies are clear and detailed • Inclusion and exclusion of reported data are thoroughly addressed • Generalizability addresses target population and other possible issues • DV demonstrates social importance • DV is supported by a magnitude of change • IV is practical and cost effective Indicator evaluation	Indicators: • Contains a complete listing of references pertinent to the study concept • Appendices are provided when appropriate Indicator evaluation

Strength of Quality	Domain I: Introductory Section	Domain II: Method Section	Domain III: Results Section	Domain IV: Discussion Section	Domain V: Other
Level 2 (Moderate)	Indicators: • Hypothesis(es)/ research question(s) is/are present but not clear • Limited application to theory or conceptual model • Significance and need for the study is not clearly demonstrated • Purpose statement does not clearly align with hypothesis(es)/ research question(s) • Some solutions to challenges are provided • Literature lacks direct connection to the purpose and justification of the study Indicator evaluation	Indicators: • Research design somewhat aligns with the hypothesis(es)/research question(s) • Data collection is limited or not clear if it was conducted throughout the course of the treatment; if appropriate baseline level is weak • Participants selected vaguely reflect the intended purpose of the study • Scope of study underrepresents population • Population does not provide a full description of inclusion and exclusion criteria • Sample technique(s) is/are described but is not replicable • Researcher(s) provide adequate information for replication of study of study and setting is adequately described • DV and IV levels, intervention, and/or conditions are adequately explained, documented, and replicable • DV is not quantifiable • IV is partially manipulated under the control of the experimenter • Participant criteria are described but lacks detail for replication • Participant confidentiality is present but not clear • Baseline data are described but may not provide evidence for repeated measurement over time • Threats to internal validity are minimally addressed Indicator evaluation	Indicators: • Percent agreement between observers is between 70% to 79%, or coefficient *r* is between 0.5 to 0.69 • Analyses of raw data are presented but are not clear • A pattern of experimental control is adequately discussed • Two different experimental effects over 2 different periods of time are presented Indicator evaluation	Indicators: • Discussion of results does not clearly address the hypothesis(es)/research question(s) • Findings are present but not all are connected to appropriate prior research • Limitations are mentioned but not clearly presented • Recommendation are mentioned but not addressed in detail • Inclusion and exclusion of reported data are addressed but are not thorough • Generalizability addresses target population and other possible issues but is limited • DV demonstrates limited social importance • DV's magnitude of change is provided but is limited • IV may be practical but is not cost effective Indicator evaluation	Indicators: • Partial inclusion of references pertinent to the study concept • Appendices are incomplete when appropriate Indicator evaluation

Strength of Quality	Domain I: Introductory Section	Domain II: Method Section	Domain III: Results Section	Domain IV: Discussion Section	Domain V: Other
Level 3 (Weak)	Indicators: • Hypothesis(es)/ research question(s) are not present • No application to theory and/or conceptual model • Significance and need for the study is not identified or is opinion based • Purpose statement dos not align with hypothesis(es)/ research question(s) • Solutions to challenges are not provided • Literature has no clear connection to the purpose and justification of the study	Indicators: • Research design does not align with the hypothesis(es)/research question(s) • No evidence of data collection was conducted throughout the course of the treatment; if necessary, no baseline level is determined • Participants selected do not reflect the intended purpose of the study • Population does not provide a description of inclusion and exclusion criteria • Sample technique(s) is/are not provided • Researcher(s) provide insufficient information for replication of study • DV and IV level, intervention, and/or conditions are inadequately explained, documented, and/or not replicable • DV is not quantifiable • IV is not manipulated under the control of the experimenter or is not addressed • Participant criteria description is not replicable • Participant confidentiality is not addressed • Baseline data are not addressed and there is no evidence of repeated measurement over time • Threats to internal validity are not addressed	Indicators: • Percent agreement between observers is $\leq$ 69%, or coefficient r is $\leq$ 0.49 • Analyses of raw data is missing and/or not clear • A pattern of experimental control is not discussed • Only 1 different experimental effect over 1 period of time is presented	Indicators: • Discussion does not address the hypothesis(es)/research question(s) • Findings are not connected to appropriate prior research • Limitations are not identified • Limited or no recommendations to future research is presented • Inclusion and exclusion of reported data are not addressed • Generalizability does not addresses target population and other possible issues • DV does not demonstrates social importance • DV does not report a magnitude of change • IV is neither practical or cost effective	Indicators: • Does not include references pertinent to the study • Appendices are not provided when needed Indicator evaluation

APAT: Level of Recommendation (Part II)



APPENDIX B

CEC QUALITY EVALUATION FOR EXPERIMENTAL AND QUASI-EXPERIMENTAL DESIGN LITERATURE

Essential Quality Indicators	**Meet Quality Indicators (Yes/No)**					
	LaGasse et al. (2019)	Stamou et al. (2019)	LaGasse (2014)	Pasiali et al. (2014)	Simpson et al. (2013)	Kalas (2012)
Description participants						
1. Sufficient information to demonstrate participants are with ASD	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
2. Appropriate sampling techniques to recruit comparable participants	**Y**	**N**	**Y**	**Y**	**Y**	**Y**
3. Sufficient information on the differential attrition	**Y**	**Y**	**N**	**Y**	**N**	**Y**
Implementation of the intervention and description of the comparison conditions						
1. The intervention is clearly described and specified	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
2. The fidelity of implementation is described and assessed?	**Y**	**N**	**Y**	**N**	**N**	**N**
3. The nature of services provided in comparison conditions is described	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Outcome measures						
1. Multiple measures closely aligned with the intervention and measures of generalized performance	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
2. Evidence of reliability and validity for the outcome measures is provided	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
3. Outcomes for capturing the intervention's effect are measured at the appropriate times	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
4. Adequate interscorer agreement is documented	**N**	**Y**	**Y**	**Y**	**Y**	**N**

Data analysis						
1. The data analysis techniques appropriately linked to key research questions and hypotheses	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
2. The variability within each sample is accounted for either by sampling or statistical techniques	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
3. A power analysis is provided	**N**	**Y**	**Y**	**Y**	**Y**	**Y**
4. The researcher clearly link the unit of analysis chosen to the key statistical analysis	**Y**	**Y**	**Y**	**N**	**N**	**Y**
The Numbers of Desirable Quality Indicators Met	**12**	**12**	**13**	**12**	**11**	**12**

APPENDIX C

CEC QUALITY EVALUATION FOR SINGLE-SUBJECT LITERATURE

Essential Quality Indicators	**Meet Quality Indicators (Yes/No)**							
	Gibbs et a (2018)	Dieringer et al. (2013)	Scalzo et al. (2015)	O'Conner (2014)	Dieringer & Porretta (2017)	Montgomery et al. (2011)	Francis (2011)	Kern et al. (2007)
Description of participants and settings								
1. Sufficient information to describe participants	**Y**	**Y**	**N**	**N**	**Y**	**Y**	**Y**	**Y**
2. Appropriate sampling techniques to recruit participants and with replicable precision	**N**	**N**	**N**	**N**	**Y**	**N**	**Y**	**N**
3. Sufficient information on the critical features of the physical setting, and allow to replication	**Y**	**N**	**N**	**N**	**Y**	**Y**	**Y**	**N**
Dependent Variables (DVs)								
1. DVs are described with operational precision	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**
2. Each DV is measured with a procedure that generates a quantifiable index	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
3. Measurement of the DVs is valid with replicable precision	**Y**	**Y**	**N**	**N**	**Y**	**N**	**Y**	**N**
4. DVs are measured repeatedly over time	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
5. Data are collected on the reliability or interobserver agreement associated with each dependent variable, and above 80%	**Y**	**Y**	**Y**	**N**	**Y**	**N**	**Y**	**N**

Independent Variable (IV)								
1. IV is described with replicable precision	**Y**	**N**	**Y**	**N**	**Y**	**N**	**Y**	**Y**
2. IV is systematically manipulated and under control	**Y**	**Y**	**N**	**N**	**Y**	**N**	**Y**	**Y**
3. Overt measurement of fidelity of implementation for IV is highly desirable	**Y**	**N**	**N**	**N**	**Y**	**Y**	**N**	**N**
Baseline								
1. includes a baseline phase and describe with replicable precision	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**Y**	N
Experimental Control/Internal Validity								
1. The design provides at least three demonstrations of experimental effects at three different points in time	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**Y**
2. The design controls for common threats to internal validity	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**N**
3. The results document a pattern that demonstrate experimental control	**Y**	**Y**	**N**	**N**	**Y**	**Y**	**N**	**Y**
External Validity								
1. Experimental effects are replicable across participants, settings, or materials to establish external validity	**N**	**Y**	**N**	**N**	**Y**	**Y**	**N**	**N**

Social Validity								
1. The DV is socially important	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
2. The magnitude of changes in the DV resulting from the intervention is socially important	**Y**	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**
3. Implementation of the IV is practical and cost effective	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
4. Social validity is achieved by implementation of the IV over extended time period	**Y**	**N**	**N**	**N**	**N**	**N**	**N**	**N**

APPENDIX D

IRB APPROVAL

Texas Woman's University
Institutional Review Board (IRB)
irb@twu.edu
https://www.twu.edu/institutional-review-board-irb/

February 27, 2020

Qin Yang
Health Promotion & Kinesiology

Re: Initial - IRB-FY2020-186 Effect of a Drums-Alive Program on Time On-task for Children with Autism Spectrum Disorder

Dear Qin Yang,

The above referenced study has been reviewed at a fully convened meeting by the TWU IRB - Denton operating under FWA00000178 and approved on February 27, 2020. If you are using a signed informed consent form, the approved form has been stamped by the IRB and uploaded to the Attachments tab under the Study Details section. This stamped version of the consent must be used when enrolling subjects in your study.

Note that any modifications to this study must be submitted for IRB review prior to their implementation, including the submission of any agency approval letters, changes in research personnel, and any changes in study procedures or instruments. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All modification requests, incident reports, and requests to close the file must be submitted through Cayuse.

Approval for this study will expire on February 26, 2021. A reminder of the study expiration will be sent 45 days prior to the expiration. If the study is ongoing, you will be required to submit a renewal request. When the study is complete, a close request may be submitted to close the study file.

If you have any questions or need additional information, please contact the IRB analyst indicated on your application in Cayuse or refer to the IRB website at http://www.twu.edu/institutional-review-board-irb/.

Sincerely,

TWU IRB - Denton

APPENDIX E

CONSENT FORM

Title: Examining the Effect of a Drums-Alive Program on On-Task Behavior for Children with Autism Spectrum Disorder

Principal Investigator: Qin Yang, M.S. ..... qyang@twu.edu 940/898-2594
Faculty Advisor: Suzanna Dillon, Ph.D..... sdillon@twu.edu 940/898-2582

Summary and Key Information about the Study

You are being asked to take part in a research study conducted by Ms. Yang as part of her graduation requirement. The purpose of this research is to look at how a special type of exercise called "Drums-Alive" (drumming on a big ball while listening to exercise music) could affect a special form of behavior called "on-task behavior" in children with ASD. Your child is being invited to participate in this study because he/she has ASD. As a participant, your child will participate in this research for approximately two months. During this research, your child will be videotaped for 20 minutes during the Drums-Alive exercises and for 20 minutes after the exercise in his /her class, (this will be done in a manner that will allow for no discomfort to your child).
We will store all videotaped material in a locked file cabinet on campus, and a coded name will be used to protect your child's confidentiality. The total time commitment for this study will be about 24 hours across 16 weeks. At the end of this study, you will receive the behavior graph report for your child's participation. There are risks during this study. The risks would be similar to a child participating in a physical education class, including fatigue. We will discuss risks and the rest of the study procedures in greater detail below.

Your child's participation in this study is completely voluntary. If you are interested in learning more about this study, please read this consent form carefully and take your time to decide whether or not you want your child to participate. Please feel free to ask the researcher any questions you have about the study at any time.

Principal Investigator Introduction

Qin Yang is a doctoral student at Texas Woman's University (TWU) in the School of Health Promotion and Kinesiology. Her specialty is teaching physical education to children with special needs. Her research interest lies in utilizing physical activity to improve physical and psychological impairments in children with neurodevelopment disorders (i.e., intellectual disabilities and autism spectrum disorder (ASD)). She has worked extensively with children with ASD for over four years and has done prior research with children with ASD.

_____
Initials

Description of Procedures

If you decide to let your child volunteer, he/she will participate in approximately 16 weeks of the Drums-Alive intervention and will be videotaped in his/her academic activity every time after each intervention. The researcher will not control any academic activity, which means it is pure observation. The child will do normal classroom activities, following their teachers' instruction. Their on-task behavior will be analyzed through videotaped academic activities. The physical activity section of this study will take approximately 20 minutes, and the video recording will take about 20 min.

Before we implement the Drums-Alive intervention, we will take approximately four weeks to observe and record your child's on-task behavior. This period is called baseline data collection. The baseline data collection will be three times per week, 20 minutes per session. The on-task behavior will be coded by using the on-task behavior checklist, which includes 1. Looking at an adult giving a direction; 2. Looking at the assignment; 3. Manipulating task materials in an appropriate manner (including cutting, writing, drawing); and 4. Following group or individual directions.

After collecting the on-task behavior baseline data, the Drums-Alive intervention protocol will be implemented three times per week, approximately 20 minutes per session for four weeks. The intervention plans include:

- **Warm-up**: approximately 3 min. Activities with physioball (big rubber ball) and music (Participants will be rolling on the physioball, dribbling or rolling the physioball, running around the physioball, etc.)
- **Drumming skills**: approximately 7 min. Drumming on the ball following the music beats (repeated hitting of the ball with drumsticks on the top of the ball, on the side of the ball, on the ground, using single or double beats in a stationary position)
- **Drums skills and movement skills**: approximately 7 min. Drumming on the ball with some movement skills with music (repeated hitting of the drumming sticks overhead, on the top of the ball, on the side of the ball, and the ground using single or double beats while walking, jogging, skipping, sliding, jumping, hopping, etc.).
- **Cool Down**: approximately 7 min. Slow rolling on the ball, sitting on the ground to stretch legs and arms, and meditation with music.

After the first four weeks of exercise, the exercise will be discontinued for another four weeks. The child's on-task behavior will be observed and recorded using the same method as the baseline. At the end of these four weeks, we will start the Drums-Alive exercises, which will be similar to the first set of activities.

Based on how the research is set up, the total exercise and observation time at this second part of the study will depend on changes observed. Importantly, the entire experimental time will be no more than 16 weeks.

_____
Initial

Potential Risks

Both the intervention and on-task behavior observation will have some potential risks. The risk and discomfort involved in this study would be similar to your child participating in a physical education class. All potential risks could include:

- Discomfort when participating in intensive physical activity, e.g., fatigue, muscle soreness, and sweating
- For the risk of emotional discomfort
- Distracted by the observer
- For the risk of coercion
- Loss of confidential information

For the risk of fatigue and sweating during the intervention, the PI will arrange a water break after each intensive activity and keep checking the student's behavior and facial expression. The PI will continually consult the participants' feelings and let the participants stop anytime when they feel uncomfortable.

For the risk of muscle soreness after the intervention, the PI will report all the activity to parents and tell parents which muscle use most in that day's intervention. During the activity time, the PI will control the intensity according to the students' abilities.

For the risk of emotional discomfort, if you or your child does not want to participate in this study, no negative penalty will be incurred. If your child wants to stop at any point, he/she needs only to notify the researcher. Additional for the emotional discomfort, this is 1:1 intervention. Therefore, other participants will not be together. If the participants not comfortable with the PI, the first class will be used to build a relationship with the participants.

For the risk of coercion, if you or your child does not want to participate in this study, no negative penalty will be incurred. If your child wants to stop at any point, he/she needs only to notify the researcher.

Concerning the loss of confidential information, the information will be protected to the extent that it is allowed by law. All critical information pass through email will be protected. All data will be stored in a file cabinet on the TWU campus, only the PI, PI's advisor, and two data analysts have access to it.

Child's video recording and any personal information collected will not be used or distributed for future research even after the researchers remove your personal or identifiable information (e.g., your child's name, date of birth, contact information).

The researchers will try to prevent any problem that could happen because of this research. Your child should let the researchers know at once if there is a problem. However, TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research. Since this study poses little risk to your child, this should not be a problem.

Participation and Benefits

The direct benefit is that the child will have access to a physical activity intervention. There is a possibility that he/she may benefit, including improving health, motor skills, and expanding the attention span. We will determine if combined movement, drumming, and music could help the child's on-task behavior. You will receive a behavior result report of your child through 16 weeks of academic work.

Confidentiality

The information collected during this study will be treated as private and privileged information. This information will not be released to any person without your consent. Your child's privacy will be protected at all times. Your child will not be identified individually in any way as a result of his/her participation in this research. The information collected, however, may be used as part of publications and papers related to on-task behavior after physical activity. However, your child, as a participant, will in no way be able to be identified as having participated in this study.

Questions Regarding the Study

You will be given a copy of this signed and dated consent form to keep. If you have any questions about the research study, please do not hesitate to ask the researchers; their contact information is at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the TWU Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

_____ _____

Participant's Parent/legal guardian Signature Date

*If you would like to know the results of this study, please tell us where you want them to be sent:

Email: _____ or Address: _____

APPENDIX F

DATA RECORDING MANUAL AND RECORDING FORM

Brief instruction

In the current study, there are **five** clients aged 4-6years will be observed through the videotapes. The behaviors that will be observed include their **verbal communication behaviors** and **task engagement behaviors**. Each of this behavior will have three operational definitions to help you code the data.

The three operational definitions of verbal communication behavior include:

- Respond to the PI's and RBT's questions verbally
- Verbally ask for help
- Initiate a verbal conversation with the PI and the RBTs

The three operational definitions of the task engagement behavior include:

- Stay on assigned activities
- Work on assigned activities
- Use the activities materials
  (Notes: Sometimes, the RBT physically hold the client to stay on the activities, this behavior should be marked as "-"; sometimes, the client was using the materials, but not do exactly the PI or IBT's order or command, this behavior could be marked as "+" or "-" depends on what he was doing. For example, in a bean bag toss activity, the client did not toss the beanbag to the box but held it on hand for more than 10s, it should be marked as "-").

For each participant, there were 6 data points for each phase and a total of four phases ($A_1B_1A_2B_2$). Each data point is 15 minutes, but there are some data that are only 10 or 11 minutes. You don't need to worry about the missing time, just code them, then I will calculate the percentage. In each 15 minutes data, it was divided into 90 intervals with 10s for each interval.

The following steps will serve as a guideline for you to code the data.

1. I created a folder for you that includes each participant's datasheet.
2. Use the attached table to write down the client's name (e.g., Ethan), Date (e.g., Day 1 4-21)
3. You can code the verbal communication behavior first or the task engagement first. For example, you want to code the task engagement first, then you should get the task engagement table ready, then start the video from the beginning. In each 10s interval, check if the client stays on assignment activities, works on assigned activities, or uses the activities materials. If any of the above-mentioned behavior occurred in this 10s interval, you need to mark a "+" in the table, then move to the next 10s interval. If in the 10s interval, the client runs away, or dazed, or does not follow instructions, you should make "-" in the table.
4. You can finish one client's all data first, or finish one phase data for all four participants, it is up to you.

Target Behavior: Verbal Communication

Operational definition:

–Respond to the PI's and RBTs questions verbally

–Verbally ask for help

–Initiate a verbal conversation with the PI or the RBTs

Name: **Date:** **Total intervals:_____**

Interval	Behavior	Interval	Behavior	Interval	Behavior	Interval	Behavior
1		24		47		70	
2		25		48		71	
3		26		49		72	
4		27		50		73	
5		28		51		74	
6		29		52		75	
7		30		53		76	
8		31		54		77	
9		32		55		78	
10		33		56		79	
11		34		57		80	
12		35		58		81	
13		36		59		82	
14		37		60		83	
15		38		61		84	
16		39		62		85	
17		40		63		86	
18		41		64		87	
19		42		65		88	
20		43		66		89	
21		44		67		90	
22		45		68			
23		46		69			

Notes:

Target Behavior: Task Engagement

Operation definition:

–Stay on assigned activities

–Work on assigned activities

–Use activities materials

Name: **Date:** **Total intervals:_____**

Interval	Behavior	Interval	Behavior	Interval	Behavior	Interval	Behavior
1		24		47		70	
2		25		48		71	
3		26		49		72	
4		27		50		73	
5		28		51		74	
6		29		52		75	
7		30		53		76	
8		31		54		77	
9		32		55		78	
10		33		56		79	
11		34		57		80	
12		35		58		81	
13		36		59		82	
14		37		60		83	
15		38		61		84	
16		39		62		85	
17		40		63		86	
18		41		64		87	
19		42		65		88	
20		43		66		89	
21		44		67		90	
22		45		68			
23		46		69			

Notes:

APPENDIX G

FIDELITY CHECKLISTS

Data Collection Procedure Fidelity

Date:	**Student:**	**Interventionist:**	**Observer:**	**Phase:**

Objective/Activity	**Recording**		
1. The PI disinfected and prepared all activity materials prior to the participants' arrival.	+	-	N/A
2. The PI instructed the participants to choose three activities out of 10 presented activities.	+	-	N/A
3. The PI presented one activity at a time and instructed the participants to change the activity every 5 minutes.	+	-	N/A
4. The PI constantly asked participants questions related to the task (e.g., what is the color of the Jenga block in your hands? what is the letter you have?)	+	-	N/A
5. When the collected at least 10 minutes of data for each session and recorded all activities using a cell phone.	+	-	N/A
			Total: () / () = ()

Intervention Procedure Fidelity

Date:	**Student:**	**Interventionist:**	**Observer:**	**Phase:**

Objective/Activity	**Recording**		
1. The PI conducted the intervention on an individual basis.	+	-	N/A
2. The PI disinfected and prepared all Drums Alive® activities materials prior to each participants' arrival (e.g., three physio balls, three pairs of drumsticks, speaker, etc.).	+	-	N/A
3. The PI always started the intervention with warm-up activities (e.g., jogging around the space, bouncing on the ball), following two to three drumming patterns, and end up with cool-down activities (e.g., stretching and breathing while sitting on the ball).	+	-	N/A
4. The PI always played age-appropriate music when participants drummed on the ball.	+	-	N/A
5. The PI implemented at least a 10-minute intervention in each intervention phases sessions prior to the data collection activities.	+	-	N/A
			Total: () / () = ()

APPENDIX H

SOCIAL VALIDITY CHECKLIST

Date:	**Interventionist:**	**Observer:**

Objective/Activity	**Recording**				
	1 Strongly Disagree	**2 Disagree**	**3 Undecided**	**4 Agree**	**5 Strongly Agree**
1. The DA intervention was appropriate and effective for their clients.					
2. The DA intervention was cost-effective, and you are willing to implement the intervention with other children.					
3. No adverse effects after participating in the DA intervention.					
4. The DA intervention activities were easy to follow and age-appropriate.					
5. The participants demonstrated enjoyment while participating in the DA intervention.					
					Total: () / () = ()